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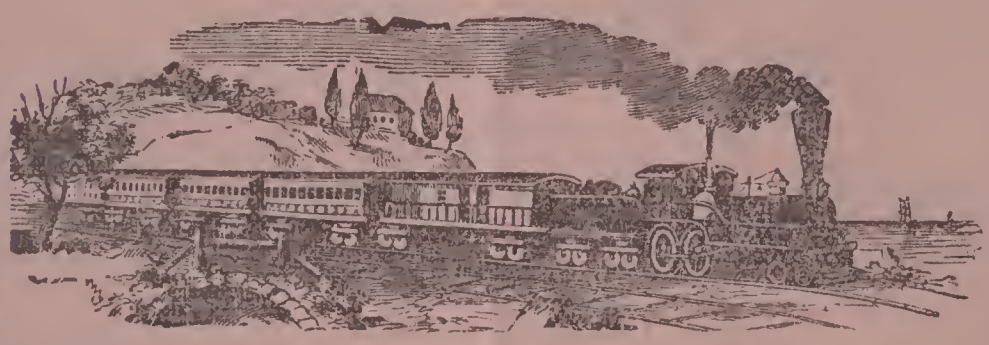
IMPROVED

RAILROAD TURN-OUT

FOR

CITY AND SUBURBAN RAILWAYS.

Patented December 22d, 1863.



A Turn-out equally adapted to either Horse or Steam Power Cars. Every part a fixture and therefore not liable to get out of order. Cars keep the right hand track by entering the Turn-out, and passing the points in straight lines at each end.

NO "PULLING OVER" OR "OFF TRACK."

WORKING PLANS WITH FULL DIRECTIONS FOR PUTTING DOWN THE TURN-OUTS;

QUANTITY OF MATERIALS FOR A TURN-OUT;

SUPER ELEVATION OF THE EXTERIOR RAILS OF RAIL-WAY CURVES;

MOTIVE POWER;

MAXIMUM GRADES;

AND THE

Relative weight or load capable of being moved on a level plane, and on different inclines, by the same power.

BY

I. N. PILLSBURY, CIVIL ENGINEER,

CLEVELAND, OHIO.

OCT., 1867.

Nevins' Printing House, Cleveland, O.

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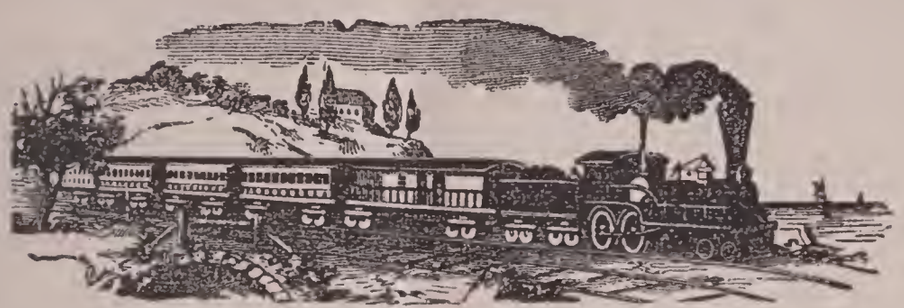

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I. N. PILLSBURY, CIVIL ENGINEER,

CLEVELAND, OHIO.

MAY, 1867.

Nevins' Printing House, Cleveland, O.]

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6-27571

GENERAL REMARKS.

Although tramways with iron rails for horse power roads were used at the collieries in England as far back as 1767; the introduction of such roads for passenger traffic along the streets of a city, is of very recent origin; and, like every other valuable discovery, invention or improvement, universally beneficial to mankind, their projectors and advocates have been assailed with the bitterest invectives and sarcasm; generally, by a class of persons who never investigate anything for themselves; and therefore are entirely ignorant of the principles and practical effect of the invention or improvement they assail; and sometimes by another class of men who have a large share of self-esteem, and desire to keep pace with popular opinion and become notorious; and therefore employ their talents, through the press and otherwise, in *ridicule, wit and sarcasm*; and are ever ready to denounce any innovation as a "*Humbug and Collusion*," or some other stereotyped words admirably suited to supply the place of sound argument and common sense in the popular minds. The opposition, by this class of men, to the introduction of any new science, invention or improvement, has existed in all ages; and will hold good from the opposers of the theory of the earth's revolution by Galileo; the science of the circulation of the human blood by Harvey; the introduction of coal as a fuel, and tallow candles for light, instead of splinters of wood; the application of steam power to Navigation by Fulton; the building of canals, turnpikes and railroads; the science of telegraphic communications by means of electricity;

and so on, step by step, down to the introduction of Gas, Coal Oil and Street Rail-Ways! In short, there has never yet been any scientific discovery, or valuable invention, or improvement introduced without opposition; and frequently, the more valuable the discovery, or useful the invention or improvement, the greater has been the opposition; and when the discovery, invention or improvement becomes established beyond the power of its opposers, so as to meet with popular favor, it is not unfrequently the case that its strongest opponents will become its warmest advocates. Such is now the case in regard to the introduction of street railways: they have passed through the ordeal, and their utility as a public convenience and safe investment of capital is fully established; so that the day is probably not far distant when the streets and avenues of all the principal cities in Europe and America will be occupied by them, with additional branch roads leading to the adjacent villages and places of public resort. Therefore the construction of city and suburban rail-ways is necessarily becoming an extensive and important branch in the department of Civil Engineering; and any improvement tending to make them less expensive and more permanent and convenient to operate, will be looked upon with interest, no matter by whom, or where the improvement is made.

EXPLANATION.

The plans, specifications and directions, in this work, are for Turnouts, especially designed for city and suburban rail-ways, for either horse power cars, or steam power with the "Dummy Engine."

The Cars enter the Turnout and pass over it in the direction indicated by the arrows. Fig. 14.—Both ends are in the same straight line. Every part is a fixture, and therefore not liable to get out of order. By the inclined guard rails at the ends, in connection with the plates, the cars are eased off from the curves to the tangents of the main track, on leaving the turnout, without any apparent jerking or jolting, even with a velocity of five or six miles an hour. Each car, upon entering the turnout, keeps the right hand track without turning from a straight line, until after all the connecting points of the two tracks are passed. The tracks reverse, or change sides in the middle; so that the turning of the cars from a straight line to pass each other is in single tracks with easy curves. This turnout is simple in its form of construction, and can be made any desired length or width between the two tracks, by varying the radii of the curves, and length of the tangents. The tracks cross each other in straight lines, thereby dispensing with the use of guard rails opposite the point of the frogs; and every part being a fixture, they are no more liable to get out of order than any other part of the road. If the meeting cars do not enter the turnout at the same time, the car entering first can pass, in a straight line, all the connecting points of the tracks before stopping, (as at B and I, Fig. 14), leaving ample room for the opposite car to pass; and thus avoid the necessity of starting upon a curve with heavy loaded cars. There is no "pulling over" or "*off track*," either upon entering or leaving the turnout; and being a fixture, of course no switchmen are required.

These turnouts are adopted and used by the railroad companies in Cleveland, and Toledo, Ohio, and Springfield, Ill.; their merits have been thoroughly tested, and their utility fully and practically demonstrated to the entire satisfaction of the parties using them; so that we are not offering this turnout for adoption by the railroad Companies gen-

erally, simply as an experiment with doubtful results; but as an improvement fully determined to be just what is required on all city and suburban railways, for either horse power, or the "Dummy Engine."

The opinions of the parties who have purchased the right and are now using them, and therefore fully acquainted with their practical working, may be found in the certificates or testimonials at the end of this work; as expressed over their own signatures.

DESCRIPTION.

In this work we give all the calculations, plans, specifications and directions complete, for putting down our turnouts on city and suburban railways, suitable for either horse or steam power cars.

First, for turnouts with fourteen degree curves, (410.3 feet radii); eight degree frogs; and for a gauge of track of four feet 8½ inches (4.70 feet); and five feet two inches (5.16 feet); fourteen degree curves being as sharp as is prudent to use without a continuous guard rail; or too great an elevation of the outer rails for the paving in the streets.

Second, for turnouts with ten degree curves (573.7 feet radii); six degree frogs; and for a gauge of track of four feet 8½ inches (4.70 feet); and five feet two inches (5.16 feet).

The last being preferable for roads of ten, fifteen, twenty-five or fifty miles in length, for the transportation of passengers and light traffic; and using steam wholly as a motive power.

Fig. 1 is a plan of the cast-iron plates and guard rail (not drawn to a scale) with the dimensions marked thereon

for the convenience of making the patterns for the castings. The curves of the plates are calculated for a central angle of three degrees and forty-three minutes, and a center radius of 159.06 feet (equal a 36deg. 38min. 34sec. curve) for a gauge of track of five feet and two inches, or 5.16 feet; but will answer equally well for any other gauge of track, the difference between the different gauges of tracks being very small as compared with the radii of the plates. The points of the plates, e and i, are set back one-half inch from a straight line, making the openings opposite the points, on the straight track, one-half inch wider than at the end of the plates, in order to avoid any liability or even possibility of the cars taking the wrong track upon entering the turnout in a straight line. And it is also well to set back the points on the left hand track, one-fourth of an inch from the true gauge line, as a matter of convenience, in case it be desired on extra occasions, to "pull over" and take the left hand track on entering the turnout: which is readily done, with horse power, without inconvenience or liability of getting off the track. A is a straight guard rail eight feet long, with two inch openings at the ends, for the flanges of the wheels, which are narrowed or inclined, from the ends, to one and $\frac{3}{8}$ inches, opening in the middle at A. By means of this inclined guard the cars upon leaving the curves of the plates, are eased off on to the tangent of the main track, without any apparent jerking or jolting. B is the inside plate, and C the outside plate. D is a section of the guard rail at a and b, and also the inside plate at b; the dotted line showing the section of the guard rail in the middle at A. E and F are sections of the inside plate, at the end, at c and d. G and H sections of the outside plate, at the end, at g and h; and I a section of the outside plate at the end j. The dimensions of the several sections, &c., are marked in inches. The spike holes in the plates, and guard rails and frogs, are

counter-sunk, in casting, for one inch square-headed spike, the holes being cast $\frac{5}{8}$ of an inch to receive $\frac{1}{2}$ inch square spike; and the center of the holes, at the ends of the plates, guard rails and frogs, are cast two inches from the ends. For the various lines, with their length, &c., necessary for marking out the patterns for the castings, see Fig. 2 and its accompanying description.

Fig. 2—Shows the various lines necessary for marking out the patterns for the cast-iron plates, B and C, Fig. 1, with corresponding letters of reference in each figure. The length of the several lines is marked thereon and given below as follows:

Plate B.—Chord bc, 10.148 feet; arc, 10.150 feet; Line bo, 10.154 feet; bd, 10.165 feet; cd, 0.330 feet; cr, rd, and ro, 0.165 feet; point, re and oe, 2.330 feet; central angle, 3deg. 43min.; radius, 159.06 feet; chord, kl, 10.309 feet; arc, 10.318 feet; line, kn, 10.332 feet; km, 10.311 feet; lm, 0.334 feet, and ln, 0.335 feet.

Plate C.—Chord, jg, 10.433 feet; arc, 10.485 feet; line, jh, 10.500 feet; jp, 10.488 feet; jt, 10.143 feet; gh, 0.340 feet; gs, sh and sp, 0.170 feet; point, gi and si, 3 feet; line, ct, 5.488 feet; ch, 5.500 feet; and gauge of track, bj, ot, and cg, 5.160 feet.

Table No. 1.

ORDINATES 1 FOOT APART FROM THE MIDDLE OF THE CHORDS b c AND j g, Fig. 2.

Inside Plate B.			Outside Plate C.		
Ordinates.	Feet.	Inches.	ordinates.	Feet.	Inches.
Middle 0	0.082	0.15¾-16—	Middle 5	0.085	1.0-16 +
1 and 1	0.079	0.15 -16 +	6 and 6	0.082	0.15¼-16—
2 " 2	0.070	0.13½-16—	7 " 7	0.073	0.14-16
3 " 3	0.054	0.10⅜-16 +	8 " 8	0.057	0.11-16 —
4 " 4	0.032	0.6-16 +	9 " 9	0.035	0. 6¾-16—
b " c	0.000	0.00	j " g	0.000	0.00

Fig. 3—Is a plan of the frog with cross-sections at the ends (not drawn to scale), as shown by the corresponding letters of reference. The width, for the rails, at the ends; the width of the spaces for the flanges of the wheels opposite the point, and the sectional dimensions are marked on the plan and sections, as those dimensions are suitable for any angle of frog; the length of the frog, the point o, the distances ag and gc, df and fb, oa, oc, od, ob, ed and eb, varying with the angle of the frog; o, being the *real angular* point of the frog; and e the point as shortened up to avoid the possibility of the flanges of the wheels running on the wrong side of the point, and thereby obviating the necessity of using guard rails in the tracks opposite the point of the frogs. On street railways we use frogs with angles varying from six to eight degrees; generally for horse power, eight degrees, and steam power with the "*Dummie*" engine, six degrees. The dimensions for an eight degree frog, are as follows:

Angle aoc and bod, eight degrees; length of frog ab and cd, six feet; ends ag, gc, bf and fd, 0.209 feet; two and a half inches full; oa, oc, ob and od, three feet; and the point eb and ed, two and a half feet.

For a six degree frog; angle aoc and bod, six degrees; length of frog, ab, and cd, 7.50 feet; ends ag, gc, bf and fd, 0.1965 feet, or 2 11-32 inches; oa, oc, ob and od, 3.75 feet; and the point eb and ed, three feet.

Fig. 4—Is a plan and sections of the cast-iron chair, $\frac{1}{4}$ full size, for the end of the guard rail at a Fig. 1. The end A is cast $5\frac{1}{2}$ inches wide and 3 inches long, with flanges $\frac{1}{4}$ of an inch square on the sides as shown in the section at A. The bed is $\frac{1}{2}$ inch thick, with opening for the spike, at the end of the plate. The end B is cast 3 inches long and 4 inches wide, with a groove a on the inside corner for the lip of the street rail, A Fig. 11, and also an opening for the spike at the end of the rail. This end is cast thicker ($1\frac{1}{8}$), in

order to bring the upper surface of the street rail even with that of the plate at a Fig 1, as shown by the sections at A and B. The end B will, of course, be made to correspond, in form and size, with the kind of rail used for the road; so as to bring the tread of the rail even, and in line with that of the plate. Two of these chairs are required for a turnout.

Fig. 5—Is a plan and section of the cast-iron chair or joint plate, $\frac{1}{4}$ size, for the end of the guard rail and plate at b, Fig. 1. It is six inches long and 5 9-16 inches wide, between the flanges, with flanges $\frac{1}{4}$ of an inch square on the sides to keep the end of the guard rail and plate even in their place. The bed is $\frac{1}{2}$ inch thick as shown by the SECTION AT A. The openings for the spike are oblong, and extend to the ends of the chairs and joint plates, to allow for the irregular punching, or unequal distances of the holes from the ends of the rails. This arrangement for the spike in the chairs and joint plates will be found very convenient in practice. Two of these are required for each Turnout.

FIG. 6.—Is a plan, and sections of the cast-iron chairs, one-fourth size, for the ends of the plates and frogs. The ends of the plates and frogs rest upon the end B; which is one-half inch thick, as shown by the section. The ends of the street rails, adjoining the plates and frogs, rest upon the end A; which is thicker than the end B, as shown by the section, on account of the difference in thickness between the plates and frogs and the street rails. In this case the end A is $1\frac{1}{8}$ inches thick; the tread of the rails on the castings being two inches thick, and that of the street rails, $1\frac{3}{8}$ inches thick, making a difference in thickness of $\frac{5}{8}$ of an inch. There is a groove, a a, on both sides of the end A, for the lip of the rail, a Fig. 11, and also openings for the spike on both sides of the ends A and B. This is done to make the same chair answer for the end c, d; g, h, or j,

Fig. 1; or a, b, c or d, Fig. 3; which it would not, except for the double grooves for the lip of the rails and openings for the spike. The end B next to A, is four inches wide and from thence narrowed in width, to three and a half inches at the opposite end, to avoid the corners of the chairs coming in contact; there being two of these chairs used, side by side, under the plates at c and d and g and h, Fig. 1. One of these chairs is required at each of the points, c, d, g, h and j, Fig. 1; and a, b, c, and d, Fig. 3; making five for each set of plates, and four for each frog; or eighteen for each Turnout.

Fig. 7—Is a section of the straight guard rail and chair at the ends a and b, Fig. 1, $\frac{1}{4}$ size; the dotted line showing the section at A, Fig. 1, in the middle of the rail. This section is also suitable for cast-iron curved rails for radii, varying from forty to eighty feet. For radii above eighty feet the height of the guard may be diminished. Two of these straight guard rails are required for each Turnout.

Fig. 8—Is a wrought iron spike for the cast iron plates, frogs and guard rails. It is one-half inch square, and five and a half inches long; with one inch square heads, made to suit the counter sinks of the holes in the castings. Thirty-six of these are required for the plates, sixteen for the frogs, and ten for the guard rails; or, sixty-two for each Turnout.

Fig 9—Is a plan, showing the manner in which the street rails are curved for the Turnout. The central chord m m, is twenty-four feet long, with ordinates (a, b, b, c, c, &c.,) at right angles therewith, and one foot apart, for getting points in the center line, m a' m', to make a pattern by which to curve the rails; and also for a center board, twelve or fourteen feet long, to lay upon the points in the center line of the tracks (Fig. 14) as a matter of convenience, to gauge from, in laying down the stringers and rails.

The rails are usually curved at the mill, where and when made; but in case of necessity they may be curved on a

large anvil by hammering on top along the inner edge of the inside rails and outer edge of the outside rails, with heavy sledges, until they are curved to suit the pattern.

The rails for the outside and inside of the track are curved in opposite directions on account of the tram for wagons; they may, however, be all curved to the radius of the center line by one pattern, there being no practical difficulty in springing them, as they are spiked down, in amount equal to the difference between the center radius and the outside and inside radii, for ten or fourteen degree curves.

The ordinates, one foot apart on the chord m m' for ten and fourteen degree curves, (center radii of 573.7 feet and 410.3 feet) are as follows:

Table No. 2.

ORDINATES ONE FOOT APART FROM THE MIDDLE OF THE CHORD m m, Fig. 9.

Ten Degree Curves; radius, 573.7 feet.			Fourteen Degree Curves; radius, 410.3 ft.		
Ordinates.	Feet.	Inches.	Ordinates.	Feet.	Inches.
Middle a a'	0.148	1 12-16 +	Middle a a'	0.175	2 1.7-16
b and b'	0.147	1 12-16	b and b'	0.174	2 1.4-16
c " c'	0.144	1 11-16 +	c " c'	0.171	2 ¾-16
d " d'	0.139	1 10-16 +	d " d'	0.165	1 15¼-16
e " e'	0.131	1 9-16 +	e " e'	0.156	1 14-16
f " f'	0.122	1 7-16 +	f " f'	0.145	1 11.8-16
g " g'	0.111	1 5-16 +	g " g'	0.132	1 9½-16
h " h'	0.097	1 3-16 —	h " h'	0.116	1 6¼-16
i " i'	0.082	1 0-16 —	i " i'	0 098	1 2.7-16
j " j'	0.065	0 12,16 +	j " j'	0.077	0 14.7-16
k " k'	0.045	0 8½-16 +	k " k'	0.054	0 10.3-16
l " l'	0.024	0 4½-16 +	l " l'	0.028	0 5⅓-16 +
m " m'	0.000	0 0-16 —	m " m'	0.000	0 0-16

For springing the rails, of different lengths, to the proper curve, we give below the Spring in inches, to the nearest sixteenth of an inch, at the middle and quarters for ten and fourteen degree curves and for lengths from ten to thirty feet. Where the sign + occurs curve a little more; and — a little less.

Table No. 3.

SPRING OF RAILS IN INCHES TO THE NEAREST 16TH OF AN INCH.

Length of rails in feet.	Ten Degree Curves ; Radius, 573.7 feet. Spring of Rails in Inches. Middle.	Quarters.	14° Curves ; Radius, 410.3 feet. Spring of Rails in Inches. Middle.	Quarters.
10	1-4 +	3-16	3-8	1-4 +
11	5-16	1-4 —	7-16	5-16 +
12	3-8	1-4 +	1-2 +	3-8
13	7-16	5-16 +	5-8 —	7-16 +
14	1-2 +	3-8	11-16	1-2 +
15	9-16 +	7-16 —	13-16	10-16 —
16	11-16 —	1-2 +	15-16 +	11-16 +
17	3-4	9-16	1 1-16	13-16 —
18	7-8 —	11-16	1 3-16	14-16 +
19	15-16	11-16 +	1 5-16 +	1 —
20	1 1-16 —	3-4 +	1 7-16 +	1 1-16 +
21	1 1-8 +	13-16 +	1 5-8	1 3-16 +
22	1 1-4 —	15-16	1 3-4 +	1 5-16
23	1 3-8 +	1 +	1 15-16	1 7-16 +
24	1 1-2	1 1-8	2 1-8 —	1 9-16 +
25	1 5-8 +	1 3-16 +	2 5-16 —	1 3-4 —
26	1 3-4 +	1 5-16	2 1-2 —	1 7-8
27	1 7-8 +	1 3-8 +	2 11-16 —	2 +
28	2 1-16 —	1 9-16 —	2 7-8 —	2 1-8 +
29	2 3-16 +	1 5-8 +	3 1-16 +	2 5-16 —
30	2 3-8 —	1 3-4 +	3 5-16	2 1-2 —

And if it be desired to determine the Spring for any other degree of curves or length of rails; the Spring at the middle, may be calculated by the following rule:

Let L equal the length of rail, and R the length of radius: then $\frac{(\frac{L^2}{2})}{l\ R} = \frac{L^2}{8R}$ the Spring in feet;

$\frac{L^2 \times 1\frac{1}{2}}{R}$ = the Spring in inches;

$\frac{L^2 \times 12}{R}$ = the Spring in eights; and

$\frac{L^2 \times 24}{R}$ = the Spring in sixteenths.

The Spring at the quarters, or at one fourth the length from the end of the rail, should be three-fourths that at the middle. The Spring for a ten degree curve and a twenty-four feet rail, at six, twelve and eighteen feet, is $1\frac{1}{8}$ inches; $1\frac{1}{2}$ inches and $1\frac{1}{8}$ inches.

Fig 10.—Is a plan, ¼ size, of a wrought iron joint plate ¼ of an inch thick for the ends of the street rails. The openings for the spike extend to the ends of the plate to allow for the irregular distance of the spike holes in the ends of the rails. This plate, the end A of the cast iron chairs, Fig. 6, and the end B of the chair, Fig. 4, are drawn to suit a four inch street rail (2 inch tread and 2 inch tram) with a lip *a* Fig. 11, and of course these widths will be changed to correspond with the kind of rail used. The end A, Fig. 4, and B Fig. 6, and the plate Fig. 5 for the plates, frogs, and guard rails, remaining the same.

Fig. 11—Is a section of the street rail, ¼ size, with two inch tread and two inch tram; weighing 35 to 38 pounds per yard.

Fig. 12—Is a plan or top view of a cast iron brace or stay, ¼ size, to be spiked on to the cross-tie and stringers to prevent the track from spreading. C is a cross-section through a b, and D a cross-section through c d, Fig's 12 and 13.

Fig. 13—Is a longitudinal section through A B, Fig. 12, or a side view, showing a section of the stringer and cross-tie, and the manner in which the stays are spiked on to the cross-ties and stringers. Both ends, A and B, are alike and the same as A Fig. 12, and the angle forty-five degrees, so that either end may be spiked on to the tie or stringer.

These stays would of course be used in connection with stringers for the flat rail, in which case they are indispensiably necessary in unpaved streets, and are preferable for tracks *even* in paved streets; as they will keep the track permanently in gauge, and do not essentially interfere with the paving.

In making this plan for stays, we have taken special pains to give the requisite strength with the smallest amount of material, the weight of each being only 1¾ pounds, thereby reducing the cost to a small sum. We consider this form far preferable to the common "angle iron" placed in the

corner of the tie and stringer; or the wooden blocks frequently used, both for utility and durability.

Fig. 14—Is a plan of the Turnout, (not drawn to a scale) with the necessary lines and letters of reference, marked thereon, for fixing the points, staking out the work and putting it down. The arrows indicate the direction in which the cars move in passing over it. For steam power roads, guard rails are put down opposite the point of the frogs; (which are unnecessary for horse power railroads) and for switching cars, and taking either track as occasion may require, a movable rail, x y, may be put in on one side of the track at each end of the Turnout, so that by moving the end x from x to v, by the lever w, the cars upon entering the Turnout, will take the left hand track; but when the Turnout is used for the passage of trains only, the levers w, w, may be fastened down; thereby leaving the Turnout properly and securely opened as shown in the plan, for the passage of trains at all times, without the aid of a switchman, as the meeting trains keep the right hand track, by entering the Turnout in straight lines; thereby avoiding the tendency to "*off track*," or liability of taking the *wrong track*, and consequent danger by the negligence or carelessness of switchmen. For city and suburban rail ways, the moveable bars and levers are not required.

Following are the dimensions of the several parts of a Turnout with fourteen degree curves (410.3 feet radii) and eight degree frogs, for a gauge of track of four feet eight and a half inches (4.70 feet); and a distance of ten feet between the centers of the two tracks; measuring at right angles with the line A O H, (Fig. 14) at the points B O and I.

Table No. 4.

Straight lines, Fig. 14, for a Turn-out of 14 degree curves.	Length in feet
From A to B	116.007
" B to O 63.859 } from B to I	127.718
" O to I, 63.859 }	
" I to H,	116 07
" A to H, extreme length	359.732
" point of frogs to A and H, on line of rails	49.768
" " " to e and j, to point of curve	8.708
" " " to f and i, " "	9.556
" e to f, and i to j, tangents crossing tracks	18.264

Table No. 5.

Centre line of tracks, Fig. 14, for a Turn-out of 14 deg. curves.	Length in feet
Tangents A B and H I	116.007
Reverse curves B C D and I J K	128.238
Curves D E and K L	57.289
Tangents E F and L M	18.264
Curves F G and M N	30.673
Curves G H and N A plates	10.318
Length of Turn-out, on center line of tracks	360.789
" " " in a straight line	359.732
Difference in length from a straight line	1.057

Table No. 6.

Distances on the straight line A O H, and offsets at right angles therewith, to points in the center line of the tracks. For turn-out of 14 degree curves, Fig. 14.

Points on line A O I	Dis. in feet from A & H	Offsets.	Length in Feet.
Ac and H *l*,	10.3106	c N and *l* G,	0.334
A d and H k,	40.8181	d M and k F,	3.465
A g and H h,	58.9043	g L and h E,	6.007
A B and H I,	116.0070	B K and I D,	10.000
B O and I O,	63.8590	O J and O C	5.000
Intermediate Distances.			
A c and H *l*,	10.3106	c N and *l* G,	0.334
c d and *l* k,	30.5075	d M and k F,	3.465
d g and k h,	18.0862	g L and h E,	6.007
g B and h I	57.1027	B k and I D,	10.000
B O and I O,	63.8590	O J and O C,	5.000

Table No. 7.

Chords and Ordinates, ten feet apart, from the middle of the chord, for the center line of the tracks; for turn-out of 14 deg. curves, Fig. 14.

Chords.	Length in Feet.	Ordinates ten feet apart.				
		20 feet. Feet.	10 Feet. Feet.	Middle. Feet.	10 Feet. Feet.	20 Feet. Feet.
A N and H G,	10.316			0.084		
N M and G F,	30.666		0.165	0.287	0.165	
L K and E D,	57.242	0.512	0.878	1.000	0.878	0.512
BC, CD, IJ&JK	64.054	0.764	1.130	1.252	1.'30	0.764
Same chords with Ordinates in inches.						
A N and H G,				1 0-16		
N M and G F,			2 0-16	3 7-16	2 0-16	
L K an d E D		6⅛	10 9-16	12	10 9-16	6⅛
BC, CD, IJ&JK		9⅛	13 9-16	15	13 9-16	9⅛
T'ng's ML&FE	18.264					

Table No. 8.

Centre radii and angles, and length of arcs for 14 degree curves, Fig. 14; turn-out plates equal a 36° 38m 34s, curve. Gauge of track, 4 feet 8½ inches.

Arcs,	Centre Radii Feet.	Centre Angles	Length of Arcs in Feet.		
			Inner.	Center.	Outer.
A N & H G Plates	159.06	3° 43' 00"	10.165	10.318	10.470
N M & G F,	410.30	4° 17' 00"	30.497	30.673	30.849
L K & E D,	410.30	8° 00' 00"	56.960	57.289	57.617
BC, CD, IJ & JK,	410.30	8° 57' 14"	63.752	64.119	64.486
Angle of frogs,		8° 00' 00"		Radii.	
Turn-out plates,		3° 43' 00"	156.710	159.06	161.41

Table No. 9.

Length of rails, exclusive of the plates and frogs, for the entire turn-out, as follows:

Straight rails for main track, 410.740		
" " for frog tangents 61.056	471.796	feet.
Curved rails for inside of tracks	429.922	"
" " " outside of tracks	434.876	"
Total for the turn-out, of 4 feet 8½ inches gauge	1,336.594	"

For a gauge of track of five feet two inches (5,16 feet) the following dimensions, other things being equal, are to be substituted, viz:

From point of frogs to A and H, read	53.025	feet,
" " " to e and j, "	11.966	"
" " " to f and i, "	6.298	"
Frog tangent, same as 4' 8½" gauge	18.264	"

Table No. 10.

In table No 8.—For length of arcs in feet, read as follows:

14 degree curves.	Guage of track 5 feet 2 inches.		
Arcs.	Length of arcs in feet.		
	Inner.	Center.	Outer.
AN and HG, Plates,	10.150	10.318	10.485
NM and GF,	30.481	30.673	30.866
LK and ED,	56.928	57.289	57.649
BC, CD, IJ and JK,	63.716	64.119	64.523
	RADII.		
Plates,	156.48	159.06	161.64

Table No. 11.

In table No. 9, read as follows:

Straight rails for main track,	410.740	471.796	feet.
" " for frog tangents,	61.056		
Curved rails for inside of tracks,		429.682	"
" " for outside of tracks,		435.122	"
Total for the Turnout of 5' 2" gauge,		1336.600	"

Following are the dimensions of the several parts of a Turnout with ten degree curves (573.7 feet radii) and six degree frogs; for a gauge of track of four feet eight and a half inches, 4.70 feet, and a distance of ten feet between the centres of the two tracks, measuring at right angles with the line A, O, H, (Fig. 14) at the points B, O, and I.

Table No. 12.

Straight lines, Fig. 14. For a Turnout of 10 degree curves.		Length in feet.
From A to B,		136.704
" B to O, 75.578	B to I,	151.156
" O to I, 75.578		
" I to H,		136.704
" A to H,		424.564
From point of frogs to A and H, on line of rails,		56.336
" point of frogs to e and j, to point of curve,		23.123
" " " " to f and i, to " " "		20.760
" e to f, and i to j, tangents crossing tracks,		43.883

Table No. 13.

Center line of tracks, Fig. 14. 10 degree curves.	Length in feet.
Tangents from A to B and H to I,	136.704
Reverse Curves, B C D and I J K,	151.596
Curves, D E and K L,	60.078
Tangents, E F and L M,	43.883
Curves, F G and M N,	22.863
Curves, G H and N A, Turnout Plates,	10.318
Length of Turnout on center line of tracks,	425.442
" " " in a straight line,	424.564
Difference in length from a straight track,	0.878

Table No. 14.

Distances on the straight line AOH, and Offsets at right angles therewith to points in the Center line of the tracks. Fig. 14.

For 10 degree curves.

Points on line A.O.H.	Dist. in Feet.	Off-setts.	Length in Ft.
Ac and Hl	10.311	cN and lG	0.334
Ad " Hk	33.094	dM " kF	2.270
Ag " Hh	76.737	gL " hE	6.857
AB " Hl	136.704	BK " ID	10.000
BO " IO	75.578	OJ " OC	5.000
	Intermediate.		
Ac " Hl	10.311	cN " lG	0.334
cd " lk	22.783	dM " kF	2.270
dg " kh	43.643	gL " hE	6.857
gB " hI	59.968	BK " ID	10.000
BO " IO	75.578	OJ " OC	5.000

Table No. 15.

Chords and Ordinates ten feet apart from the middle of the Chord, for the Center line of the tracks. Fig. 14. Ten deg. curves.

Chords.	Length in feet.	Ordinates ten feet apart.						
		30 feet.	20 feet.	10 feet.	Middle	10 feet	20 feet	30 feet.
		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet
AN & HG Plates,	10.316	.....	.....	.....	0.084	.....	.....	.....
NM & GF.....	22.861	.....	.....	0.027	0.114	0.027	.....	.....
LK & ED.....	60.050	.....	0.437	0.699	0.786	0.699	0.437	.....
BC, CD, IJ & JK.	75.743	0.467	0.903	1.165	1.252	1.165	0.903	0.467
Same Chords	with	Ordinates in inches.						
AN & HG Plates,	10.316	.....	.....	.....	$1\frac{0}{16}$	.....	.....	.....
NM & GF.....	22.861	.....	.....	$\frac{5}{16}$	$1\frac{3}{8}$	$\frac{5}{16}$	.....	.....
LK & ED.....	60.050	.....	$5\frac{1}{4}$	$8\frac{3}{8}$	$9\frac{7}{16}$	$8\frac{3}{8}$	$5\frac{1}{4}$	.....
BC, CD, IJ & JK.	75.743	$5\frac{5}{8}$	$10\frac{13}{16}$	14	15	14	$10\frac{13}{16}$	$5\frac{5}{8}$
Tangents ML&FE	43.883	.....	.....	.....	.....	.....	.....	.....

Table No. 16.

Center radii and angles; and length of arcs, for ten degree curves. Fig. 14. Turnout plates, Center radius equal a 36° 38' 34" curve. Gauge four feet 8½ inches.

Arcs.	Center Radii. Feet.	Central Angles,	Length of Arcs in feet.		
			Inner.	Center.	Outer.
AN & HG Plates,	159.06	3° 43' 00"	10.165	10.318	10.470
NM & GF	573.70	2° 17' 00"	22.768	22.863	22.956
LK & ED	573.70	6° 00' 00"	59.831	60.078	60.324
BC, CD, IJ & JK	573.70	7° 34' 12"	75.487	75.798	76.108
Angle of	frogs.	6° 00' 00"		Radii	
Tangent Plates,	159.06	3° 43' 00"	156.71	159.06	161.41

Table No. 17.

Length of rails, exclusive of the plates and frogs, for the entire Turnout, as follows:

Straight Rails for the main track,.....490.532 }
" " for frog tongents,.....160.532 } 651.064 feet.
Curved Rails for inside of tracks,..... 467 146 "
" " for outside of tracks,..... 470.992 "

Total for the turnout of 4' 8½" gauge.....1589.202 feet.

For a gauge of track of five feet two inches, 5.70 feet, the following dimensions—other things being equal—are to be substituted in the foregoing Tables, No. 12, 16 and 17, viz:

In Table No. 12, from point of frogs to A and H read, 60.723 feet.

From point of frogs to e and j to point of curve, read.. 27.514 feet.
From point of frogs to f and i to point of curve, read.. 16.369 "

Frog tangents, same as for a 4' 8½" gauge..... 43.883 feet.

Table No. 18.

In table No. 16, for length of arcs in feet, read as follows:

Arcs.	Length of Arcs in Feet.		
10 Degree Curves.	Inner.	Center.	Outer.
A N and H G, Plates.....	10.150	10.318	10.485
N M and G F.....	22.760	22.863	22.965
L K and E D.....	59.807	60.078	60.348
BC, CD, IJ and JK.....	75.457	75.798	76.139
		RADII.	
Turn-out Plates.....	156.48	159.06	161.64

Table No. 19.

In Table No. 17 read as follows:

Straight rails for main track, 490.532 }
do for frog tangents, 160.532 } 651.064 feet.
Curved rails for inside of tracks..... 466.962 "
do for outside of tracks..... 471.182 "

Total for the turn-out of 5' 2" gauge.....1589.208 "

DIRECTIONS FOR PUTTING DOWN THE TURN-OUTS.

First for fixing the points and putting in a fourteen degree turn-out with eight degree frogs. Having determined the location of the turn-out, run the straight line, in the center of the street or main line of the road, A, O, H, (fig. 14). Fix a center peg and nail at A, and measure 116.007 feet, from A to B, and fix the point B; thence 63.859 feet, from B to O, and fix the point O; thence 63.859 feet, from O to I, and fix the point I; thence 116.007 feet, from I to H, and fix the point H; making the length of the turn-out from A to H, on the line A, O, H, 359.732 feet. Then put down the plates at each end, with the first or small ends opposite the points A and H, at right angles with the line A, O, H; and the straight guard rails a, a, (A fig. 1,) connecting with the inside plates, b, b, (B fig. 1.) Then put down the frogs, placing the *real* points (O fig. 3) 49.768 feet from the ends of the plates, opposite the points A and H, for a gauge of track of 4 feet and 8½ inches; or, 53.025 feet from the same points for a gauge of five feet two inches. The chairs for the plates, frogs and guard rails are described under their respective Figs. 4, 5 and 6. Then measure on the line A, O, H, (as in table No. 6,) 10.311 feet from A and H to c and l; and at right angles therewith, the offsets 0.334 feet to the points N and G. Then measure 40.818 feet from A and H to d and k; and at right angles, the offsets, 3.465 feet to the points M and F. Then measure 58.904 feet from A and H to g and h; and at right angles, the offsets, 6.007 feet to the points L and E. Then from the points B and I, measure at right angles, 10.000 feet to the points K and D. Then from the point O, measure at right angles, five feet each way to the points J and C; fixing stakes and nails at the points N, G, M, F, L, E, K, D, J and C. Then from the chord lines N M and G F, 3 0.666 feet); L K and E D (57.242 feet); and B, C C D, I

J and J K, (64.054 feet each) measure at right angles and put in their respective ordinates (ten feet apart each way from the middle of the chord) corresponding in length with the numbers given in table No. 7; fixing center stakes and nails at the end of each ordinate; thus fixing points in the center line of the tracks from which, with the aid of a center board, (having one edge rounded to a fourteen degree curve as explained under fig 9), a continuous center line is formed to gauge from in putting down the stringers and rails on the curves; and a small line stretched between the points A B, H I, M L, and F E, forms continuous lines for gauging the tangents. The length of the tangents will be found in tables No. 4 and 5, and the length of the rails for the outside and inside of the curves will be found in table No. 8 for a gauge of track of 4 feet 8½ inches; and in the subsequent reference to table No. 8 for a gauge of 5 feet 2 inches. The total quantity of straight and curved rails for the entire turn-out will be found in table No. 9 for a 4 feet 8½ inch gauge; and in the subsequent reference to table No. 9 for a 5 feet two inch gauge.

In surfacing up the turn-out, the outside of the curves should be elevated above the inside not less than one-half an inch, nor more than one and a half inches, according to the required velocity in passing over; we use one-half inch for horse-power roads in paved streets. The left hand side of the straight track, from a point forty or fifty feet back from the ends of the switch to the ends of the tangents at B and I, should also be elevated one-half inch above the right hand side, so that the cars upon entering the turn-out will the more readily pass the points of the plates and frogs under all circumstances of carelessness of drivers or otherwise; this, although a small element of and in itself, is a precaution that should not be overlooked or neglected in putting down the turn-outs for either horse or steam power roads. Great care should also be taken to have the

cross-ties thoroughly tamped, so as to keep all parts of the turn-out firmly in their place. The cast iron stays (fig. 12) should be spiked on to every cross-tie against the outside of the stringers, to avoid the possibility of the spreading of the tracks ; they are equally necessary where the streets are paved with stone, but are not required in the "Nicholson" pavement. In putting down the turn-out in connection with the street paving, we commence at one end of the turn-out, put down the plates and guard rail, and continue with both tracks together, keeping our points in advance of the work through the entire length of the turn-out. In the "Nicholson" pavement, where no cross-ties (only inch flooring) are used, we elevate the outside of the curves on the left hand side of the track on entering the turn-out, by using stringers one-half inch deeper for the elevated portion. The proper depth of stringers for a turn-out in the "Nicholson" pavement, for a street rail $1\frac{3}{8}$ inches thick, is $4\frac{1}{8}$ inches for the inside of the curves and lower side of the straight track ; and $4\frac{5}{8}$ inches for the outside of the curves and the elevated side of the straight track, the blocks of pavement being six inches in depth.

Second, for fixing the points and putting in a ten degree turn-out with six degree frogs. Run as before, the straight line, in the center of the street or main track, A O H, (fig. 14). Fix a center peg and nail at A, and measure 136.704 feet, from A to B, and fix the point B ; thence 75.578 feet, from B to O, and fix the point O ; thence 75.578 feet, from O to I, and fix the point I ; thence 136.704 feet, from I to H ; making the length of the Turnout from A to H, on the line AOH, 424.564 feet. Then put down the plates at each end, with the first or small ends opposite the points A and H, at right angles with the line AOH, and the straight guard rails a.a, (A Fig. 1) connecting with the inside plates b.b, (B Fig. 1). Then put down the frogs, placing the *real* points (o Fig. 3) 56.336 feet from the ends

of the plates, opposite the points A and H, for a gauge of track of four feet 8½ inches; or, 60.723 feet from the same points for a gauge of five feet two inches. The chairs for the plates, frogs and guard rails are described under their respective figures 4, 5 and 6. Then measure on the line AOH, (as in Table No. 14), 10.311 feet, from A and H to c and l; and at right angles therewith, the offsets, 0.334 feet to the points N and G. Then measure 33.094 feet from A and H to d and k; and at right angles, the offsets, 2.270 feet to the points M and F. Then measure 76.737 feet, from A and H to g and h; and at right angles, the offsets, 6.857 feet to the points L and E. Then from the points B and I, measure at right angles 10.000 feet to the points K and D. Then from the point O, measure at right angles, five feet each way to the points J and C; fixing stakes and nails at the points N, G, M, F, L, E, K, D, J and C. Then from the chord lines NM and GF, (22.861 feet); LK and ED (60.050 feet); and BC, CD, IJ and JK (75.743 feet each), measure at right angles, and put in their respective ordinates (ten feet apart each way from the middle of the chord) corresponding in length with the numbers given in Table No. 15; fixing center stakes and nails at the end of each ordinate; thus fixing points in the center line of the tracks from which, with the aid of a center board (having one edge rounded to a ten degree curve as explained under Fig. 9) a continuous center line is formed to gauge from in putting down the stringers and rails on the curves; and a small line stretched between the points AB, HI, ML and FE forms continuous lines for gauging the tangents. The length of the tangents will be found in Tables number 12 and 13; and the length of the rails for the outside and inside of the curves, will be found in Table No. 16 for a guage of track of four feet 8½ inches; and in the subsequent reference to Table No. 16, for a gauge of five feet two inches. The total quantity of straight and

curved rails for the entire Turnout will be found in Table No. 17, for a four feet 8½ inches gauge; and in the subsequent reference to Table No. 17, for a five feet two inches gauge.

With reference to the surfacing up the Turnout, tamping the cross-ties, elevating the outside of the curves, and the left hand side of the straight track, staying the stringers to prevent spreading, putting down the Turnouts in connection with street paving, and the depth of the stringers, &c.; the same remarks made with reference to the fourteen degree Turnouts are equally applicable to the putting down of the ten degrees.

QUANTITY OF MATERIALS FOR A TURNOUT.

184 cubic yards of Earth Excavation, supposing the surface of the street to be at grade.

200 Cross-ties 6" × 6" length 1¾ feet more than the gauge of track.

1443 linear feet of Stringers 4" × 6" or 5" × 6" according to width of rail.

445 yards of street rails.

60 wrought iron joint Plates, Fig. 10, 6" × 3¾" × ¼"..... 90 lbs.

200 Cast Iron Stringer Stays, Fig. 12. Wooden blocks may be substituted, but the iron ones are preferable..... 350 "

4 Cast iron plates, 2 of B and 2 of C, Fig. 1, weight,.....1240 "

2 Cast iron guard rails, A Fig. 1; Section Fig. 7, weight,. 496 "

2 Cast iron frogs, Fig. 3,....."..... 436 "

22 Cast iron chairs, Fig's. 4, 5, and 6,....."..... 120 "

62 Square-headed Spikes, 5¼ × ½, Fig. 8, for Castings, 31 "

Street rail Spike, 4½" × ½",.....weight.. 275 "

Stringer Spike, 10" × 7-16",....."..... 300 "

500 Square yards of paving.

The above quantities are for both tracks; only one of which properly belongs to the Turnout. For a Turnout outside of the corporation, with T rail, the Stringers, Stringer Spike, Cast Iron Stringer Stays and paving, of course, will not be required; but Cast iron Chairs and hook-headed Spike should be used in place of the wrought iron joint plates and the common street rail spike.

SUPER-ELEVATION OF THE EXTERIOR RAILS.

When a material body moves in a circle, the normal force acts *radially inwards*, and hence is called the *centripetal force;* while the force that the body opposes, by virtue of its inertia, which acts *radially outwards*, is called the *centrifugal force.* The *centripetal* force is that which acts directly upon the body; the *centrifugal* force is the reacting force of the body.

In the revolution of the planets around the sun, these forces are equal in amount and opposite in direction.

In railway curves of large radii the centrifugal force of the train is counteracted by the conical inclination of the tire of the wheels, which is usually from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in the whole width of the tires of from $3\frac{1}{2}$ to 5 inches. But in curves of less than 1500 or 2000 feet radii, it becomes absolutely necessary to elevate the exterior rails to counteract the centrifugal force produced by the weight and velocity of the train, since all moving bodies have a tendency to continue their motion in a direct line.

The conical inclination of the tire of the wheels, together with the force of gravity, by the super-elevation of the exterior rails of the curve, constitute the *centripetal force* of the train; while the force tending to make the train leave the curve by its weight and velocity and move in a tangent, constitutes the *centrifugal force.* And as these forces act in contrary directions, it is evident that they will hold each other in equilibrium when they become equal, and the train has no tendency to quit the curve.

Let W equal the weight of the train;

" V its velocity in feet per second;

" G the force of gravity at the earth's surface, usually taken at 32.2 feet, and therefore a constant number;

Let R the center radius of the curve; and

" R' the radius of a circle which the center of gravity of the train will describe in consequence of the conical inclination of the tires of the wheels.

Let F equal the *centrifugal force* of the train;

" F' the *centripetal force* corresponding to the radius R';

" F" the *centripetal* force caused by the super-elevation of the exterior rail;

" E the super-elevation of the exterior rail, in feet and decimals; and

" w the width between the rails, or gauge of track.

The *centrifugal force* will then be represented by

$$F = \frac{W V^2}{G R}. \qquad (1)$$

The *centripetal force* corresponding to the radius R' will be

$$F' = \frac{W V^2}{G R'}. \qquad (2)$$

The inclination of the plane on which the train moves is equal to the super-elevation of the exterior rail divided by the gauge of the track, $= \frac{E}{w}$; therefore the *centripetal force* caused by the super-elevation of the exterior rail will be

$$F'' = \frac{W E}{w}. \qquad (3)$$

These two last forces $\frac{W E}{w} + \frac{W V^2}{G R'}$ constitute the *centripetal* force of the train; and the force $\frac{W V^2}{G R}$ the *centrifugal* force. And when these two forces become equal, that is, when $\frac{W E}{w} + \frac{W V^2}{G R'} = \frac{W V^2}{G R}$ or R'=R, they will hold each other in equilibrium, and the train will have no tendency to leave the curve. Hence the general formula adopted for the super-elevation of the exterior rail, for curves of less than 1500 or 2000 feet radius, is,

$$E = \frac{W V^2}{G} \left(\frac{1}{R} - \frac{1}{R'}\right) \qquad (4)$$

For the value of R' let d= the mean diameter of the wheels of the train; $\frac{1}{n}$= the inclination of the tire, usually

$\frac{1}{2}$ inch in $3\frac{1}{2}$ inches, $=\frac{1}{7}$; and s= the deviation of the wheels, = say $\frac{1}{3}$ to $\frac{1}{2}$ an inch. Then when the two forces are in equilibrium,

$$R' = \frac{w\,d\,n}{4\,s}; \qquad (5)$$

In which w= the gauge of the track as above.

If w= 4.7 feet; d= 3 feet; $\frac{1}{n}=\frac{1}{7}$ and s= $\frac{1}{3}$ of an inch; then $R' = \frac{w\,d\,n}{4\,s} = 4.7\times3\times7\div4\times\frac{1}{3}\times\frac{1}{12} = 98.7\div\frac{16}{144} = \frac{98.7\times144}{16} =$ 888.3 feet.

For curves of less than 1500 or 2000 feet radius a super-elevation of the exterior rails will be absolutely necessary to counteract the excess of the centrifugal force above the centripetal. Therefore, for greater safety the value of R' above should be limited to not less than 1500 or 2000 feet.

It must, however, be admitted that it is impossible in practice to conform to the precise conditions and proportions determined by strict mathematical formula. The impracticability of running the trains exactly in conformity with their calculated velocity, the different and variable weight of the trains, the accidental and irregular depressions of the track, &c., will unavoidably derange these conditions; so that the results of these computations, in practice, can only be close approximations.

For all practical purposes, the super-elevation of the exterior rail may be calculated by the following rule:

Multiply the square of the velocity of the train, in feet per second, by the width of the track, and divide the product by the product of the force of gravity, (32.2 *feet,*) *multiplied by the radius of the curve, and to the quotient add* 0.02092 *feet for the required elevation of the outer rail in feet and decimals, the other measures being also in feet.*

In which case formula (4) becomes,

$$E = \frac{w\,v^2}{G\,R} + 0.02092 = \frac{w\,v^2}{32.2\,R} + 0.02092. \qquad (6)$$

For a general table of super-elevations of the exterior rail, the width of the track, w, may be taken as an unit, and then the numbers corresponding with the different radii of curves and velocity of trains, need only to be multiplied by the required gauge of the track in feet, and to the product add 0.02092 for the super-elevation of the exterior rail, in feet and decimals, for that gauge. In which case formula (6) becomes,

Table No. 20.

Curves.		The numbers in these columns are to be multiplied by the gauge of the track, and to the product add 0.02092 for the super-elevation of the exterior rail in decimals of a foot. These numbers $=\frac{v2}{32.2R}$							
Central Angle subtended by 100 feet Chord.	Cent'l radius in feet.	Velocity of the train in miles per hour.							
		3m.	4m.	5m.	10m.	15m.	20m.	25m.	30m.
1°	5730.0	.....	.....	.....	0.00116	0.00262	0.00466	0.00729	0.01049
2°	2865.0	.....	.....	.....	0.00233	0.00524	0.00932	0.01458	0.02098
3°	1910.0	.....	.....	.....	0.00349	0.00786	0.01398	0.02186	0.03148
4°	1433.0	.....	.....	.....	0.00466	0.01048	0.01864	0.02914	0.04195
5°	1146.0	.....	.....	.....	0.00583	0.01312	0.02331	0.03644	0.05246
6°	955.4	.....	.....	.....	0.00699	0.01573	0.02796	0.04371	.....
7°	819.0	.....	.....	.....	0.00816	0.01835	0.03262	0.05099	.....
8°	716.8	.....	.....	.....	0.00932	0.02096	0.03727	0.05826	.....
9°	637.3	.....	.....	.....	0.01048	0.02358	0.04192	0.06553	.....
10°	573.7	.....	.....	0.00291	0.01165	0.02620	0.04656	0.07279	.....
11°	521.7	.....	.....	0.00319	0.01281	0.02881	0.05121	.....	.....
12°	478.3	.....	.....	0.00348	0.01397	0.03142	0.05585	.....	.....
13°	441.7	.....	.....	0.00377	0.01513	0.03403	0.06048	.....	.....
14°	410.3	.....	0.00259	0.00406	0.01629	0.03663	0.06511	.....	.....
15°	383.1	.....	0.00278	0.00435	0.01744	0.03923	.....	.....	.....
20°	287.9	.....	0.00370	0.00579	0.02321	0.05221	.....	.....	.....
25°	231.0	.....	0.00462	0.00722	0.02893	0.06507	.....	.....	.....
30°	193.2	0.00311	0.00552	0.00863	0.03459	.....	.....	.....	.....
35°	166.3	0.00361	0.00641	0.01003	0.04019	.....	.....	.....	.....
40°	146.2	0.00411	0.00729	0.01141	0.04571	.....	.....	.....	.....
60°	100.0	0.00601	0.01067	0.01668	0.06683	.....	.....	.....	.....
84°39'14"	75.0	0.00801	0.01422	0.02225	.....	.....	.....	.....	.....
112°53'07"	60.0	0.01002	0.01777	0.02781	.....	.....	.....	.....	.....
180°00'00"	50.0	0.01202	0.02133	0.03337	.....	.....	.....	.....	.....
.....	40.0	0.01503	0.02666	0.04171	.....	.....	.....	.....	.....

$$E = \frac{v^2}{G\,R} W + 0.02092 = \frac{v^2}{32.2\,R} W + 0.02092. \qquad (7)$$

Ex. 1.—Required the super-elevation of the exterior rail for a curve of fifty feet radius, with a velocity of five miles per hour, and a gauge of track of 4 feet 8½ inches (4.7 feet.) In the column of five miles per hour and against fifty feet radius, take the number 0.03337 and multiply it by 4.7 feet (the gauge of track,) and to the product add 0.02092 feet, and the sum will be the required super-elevation of the

exterior rail, in decimals of a foot; which multiplied by 12, will give the same in inches. Thus $0.03337 \times 4.7 + 0.02092 = 0.177759$ of a foot; $= 2.133108$, or say $2\frac{1}{8}$ inches.

Ex. 2.—With the same radius of curve and velocity as above, for a gauge of track of five feet two inches (5.16 feet,) the super-elevation of the exterior rail will be, $0.03337 \times 5.16 + 0.02092 = 0.1931092$ of a foot, or say $2\frac{1}{8}$ inches. And so on for any radius of curve and velocity in the table, and for any gauge of track.

In the arrangement of the above table, we have considered the conical inclination of the wheels to be such as not to require a super-elevation of the exterior rail for curves of large radii. From one to ten degrees, with velocities less than ten miles per hour; from ten to fourteen degrees, with velocities less than five miles per hour; and from fourteen to thirty degrees, with velocities less than four miles per hour. And also that trains should not run at a greater speed than thirty miles per hour on curves of from one to five degrees; nor greater than twenty-five miles per hour on curves of from five to ten degrees; nor greater than twenty miles per hour on curves of from ten to fourteen degrees; nor greater than fifteen miles per hour on curves of from fourteen to twenty-five degrees; nor greater than ten miles per hour on curves of from twenty-five to sixty degrees; and not greater than five miles per hour on curves of from one hundred feet to forty feet radius.

For the convenience of those who may wish to extend the above table, we insert the following table of the velocities in feet per second, corresponding with the different rates of motion in miles per hour, together with the squares of the velocity in feet per second:

Table No. 21.

Velocity in miles per hour.	Velocity in feet per second.	Square of the velocity in feet per second.	Velocity in miles per hour.	Velocity in feet per second.	Square of the velocity in feet per second.
3	4.40	19.3600	14	20.53	421.4809
4	5.86	34.3396	15	22.00	484.0000
5	7.33	53.7289	20	29.33	860.2489
6	8.80	77.4400	25	36.67	1344.6889
7	10.26	105.2676	30	44.00	1936.0000
8	11.73	137.6129	35	51.33	2634.7689
9	13.20	174.2400	40	58.66	3440.9956
10	14.67	215.2089	45	66.00	4356.0000
11	16.13	260.1769	50	73.33	5377.2889
12	17.60	309.7600	55	80.66	6506.0356
13	19.06	363.2836	60	88.00	7744.0000

MOTIVE POWER.

Hitherto the principal motive power employed on City and suburban railways, has been that of horses; but the day is coming, and we hope not far distant, when that of steam will be substituted. Yet, like every other valuable improvement, it must pass the ordeal of popular fallacies, before it can become in general use.

The stretching of telegraphic wires along public roads, has been considered, by some, as endangering the lives of persons passing along in a thunder storm, by a supposed liability in consequence thereof, of being struck by lightning! But that phantom has vanished; and the "*scare*" about the danger from using the "Dummy Engine" along the streets and avenues of a city and the public highways will also soon disappear.

Practical experience has already proved the superiority of the steam cars over the horse cars for City and Suburban railways. In proof of which we will quote from Messrs. Grice & Long of Philadelphia:—

"They are more efficient, economical, reliable, powerful, safe, and comfortable; they make no dirt or filth in the streets; occupy far less room than horse cars; and at the same time accommodate forty per cent. more passengers, and have power to draw three

additional ordinary cars, with passengers, at a cost not exceeding eighty per cent. of that one car drawn by animals. *Their power to ascend grades and round curves is greater than the horse car.* They are more safe and more controlable, because the engineer can reverse the action of the power immediately, which cannot be done by a driver of a horse car. Another advantage is, they are heated by steam in winter, by means of pipes, and consequently are always dry and comfortable. The "Dummy," as its name implies, makes no noise; the engine and boilers are located on the front platform; and occupy a space in length of about four feet, including room for coal and oil; the length of the body of the cars varies from sixteen to twenty feet, and the width from seven and a half to eight and three fourths feet, length, including platforms, from twenty-two and a half to twenty-seven feet; weight of car and engine from five and a half to seven and a fourth tuns; power from ten to twenty horse. The steam cars have trucks under their rear ends and will run safely on curves as sharp as fifty feet radii; and on grades as steep as six feet in one hundred; they will seat thirty-five passengers, with standing room for sixty-five more; the Dummy will run from sixty to one hundred miles per day at a cost of from eight to ten dollars, including engineer and conductor; it consumes from four to eight pounds of coal per mile, average about six pounds."

From the above it will readily be perceived that our fourteen degree Turnouts (Fig. 14) are equally adapted to the steam cars with the "Dummy Engine"; so that the railroad Companies who have already, or may subsequently, put in the fourteen degree Turnouts with eight degree frogs, according to the accompanying directions and plan (Fig. 14) for horse power roads only, can at any time substitute steam power with the "Dummy Engine" on their roads without any change or alteration in the turnouts or curves.

MAXIMUM GRADES.

The amount of power or force necessary to move a body of a given weight along a horizontal plane, and also the requisite power to move the same body on planes of different inclinations, is an important problem connected with the transportation of passengers and traffic along either a common road or a railway line.

When a locomotive engine commences its motion, its power exceeds the resistance, and therefore the speed of the engine continues to increase until the resistance becomes equal to the power of the engine; then the motion of the engine will be uniform, and the train moving with its greatest velocity or maximum speed, the work destroyed by the resistance being then exactly equal to the power exerted by the locomotive engine.

It has been found by experiment that the retarding force or resistance by friction, on a given surface, is a certain proportionate part of the weight of the body moved; and that it is not affected by the rate of motion, nor by the extent of the rubbing surface. Thus if the body rest on a horizontal plane, and it be drawn horizontally by a weight attached to a cord passing over a pulley: then the weight which is just sufficient to draw the body along the plane, will measure the friction of the body on that plane.

The friction on a horizontal plane, is found to be *directly* proportioned to the load, and *inversely* proportioned to the diameter of the wheels.

From the experiments made upon this subject, the friction of a loaded vehicle drawn along a horizontal plane:

On a well made pavement, is about.....1-70 of its whole weight.
On a road of broken stone, laid upon a pavement or a concrete base,.....1-48 " " "
On a road with a thick coating of broken stone laid on earth,.....1-34 " " "
On a smooth McAdamized road,.....1-30 " " "
On a common Turnpike road,.....1-24 " " "
On a road with a thick coating of gravel, laid on earth,.....1-15 " " "
For a loaded car on a street railway, from 1-120 to 1-150 "
For a loaded car or train, on a locomotive railway, from.....1-200 to 1-280 "

On Locomotive railways the friction on a level plane, is usually taken at 1-280 of the weight of the train; yet we

think that 1-200 would be more nearly the average amount of friction for the train on a level road, or 10 pounds per tun of 2000 pounds. For Street railways, on account of dirt and other extraneous matter liable to accumulate on the rails, in connection with the undulations or uneven surface of the rails themselves, the average amount of friction, or the tractive force on a level road, may be taken at 1-125 of the weight of the car and its load; or 16 pounds per tun of 2000 pounds.

The above fractions may therefore be taken as the co-efficients of friction due to each particular plane; or that portion of the weight of the whole body necessary to move it along the horizontal plane at a slow rate of speed. Therefore, the *tractive force*, or the power necessary to move the body along the horizontal plane, is equal to the weight of the body, divided by the co-efficient of friction due to that particular plane. Or, in mathematical language, let F equal the tractive force, or the power necessary to move the body along a horizontal plane; W the weight of the body; and C the co-efficient of friction of the body on that plane: then $F = \frac{W}{C}$. (1)

Ex. 1.—For a street car weighing, with its maximum load, six tuns or 12000 pounds, and taking the co-efficient of friction at 1-125 of its weight, then the force F, necessary to move the car along a level plane, will be $F = \frac{12000}{125} =$ 96 pounds = the tractive force; equals 16 pounds per tun of 2000 pounds.

For the power requisite to move a train along planes of different inclinations or grades, let W = the weight of the train; h the rise, in feet, of the inclined plane in every 100 feet of its length; c the co-efficient of friction:—F= the friction or tractive force $= \frac{W}{C}$; P = the power requisite to draw the weight, W, *including* its friction, F, along the

inclined plane; and x = the power required to draw the weight, W, along the plane, *exclusive* of the friction, F. Then as,

$$x : W :: h : 100; \text{ whence } x = \frac{h\,w}{100};$$

$$\text{but } P = x + F = \frac{hw}{100} + \frac{W}{c} = \frac{100 + hc}{100\,c}\,W; \qquad (2)$$

$$\text{therefore } W = \frac{100\,c\,P}{100 + hc}. \qquad (3)$$

That is for the requisite power to draw a train up a given grade; by equation (2), *multiply the rise, in feet, of the grade in* 100 *feet, by the co-efficient of friction, and to the product add* 100; *then divide the sum by the product of the co-efficient of friction, multiplied by* 100; *and then multiply the quotient by the weight of the train*, for the required power.

Ex. 2.—On a railway grade of one foot rise in 100 feet; what power will be required to draw the car, as in Ex. (1), with its maximum load of six tuns up the grade, the co-efficient of friction being $\frac{1}{125}$ or c = 125?

By equation (2) $P = \frac{hc + 100}{100\,c}\,W = \frac{1 \times 125 + 100}{100 \times 125} \times 6 \times 2000$ $= 0.018 \times 6 \times 2000 = 216$ pounds; or 120 pounds more than is required to draw the same load on a horizontal plane.

In accordance with the above formula, the following Table has been calculated for the purpose of showing with sufficient accuracy for practical purposes the force required to draw or propel a street railway car with its maximum load of six tuns, or 12000 pounds, including friction, on a level track, and up gradients with inclinations varying from one foot to ten feet in one hundred feet; or from 52.8 feet to 528 feet per mile. The weight of the two horse car is taken at 3600 pounds with a maximum load of 56 passengers, averaging 150 pounds each, or together 8400 pounds, making in all 12000 pounds or six tuns net.

The first column contains the ratio of inclination; the second column contains the vertical rise in feet for each

100 feet of the incline; the third column contains the vertical rise in feet per mile; the fourth column contains the angle of inclination that the gradient makes with the horizontal; the fifth column contains the number of pounds requisite to move the car with its maximum load of six tuns, including friction, along a level plane and on different inclined planes from one to ten feet in each hundred feet of the inclined plane; and the sixth column contains the number of pounds required to move a tun of 2,000 pounds on a level plane, and also on the above inclined planes. The numbers in the 5th column are the results of equation (2) in which $P = \frac{100 + hc}{100\ c}\ w$; h being the vertical rise in feet for each 100 feet of the inclined plane; c, the co-efficient of friction ($\frac{1}{125}$ of the load,) and w, the weight of the car and its maximum load of six tuns of 12,000 pounds; and the numbers in the sixth column are $\frac{1}{6}$ of those in the 5th column; the numbers in the 5th column being the amount of tractive force requisite to move a load of six tuns along the different gradients.

Table No. 22.

Rate of Inclination.	Vertical Rise for each 100 feet of the incline, in feet.	Vertical Rise in a mile, in feet.	Angle of Inclination which the gradient makes with the horizontal.	Force required to draw the car with its maximum load of 6 tuns (12,000 lbs.) on a level up the different inclines, including friction	Force required to draw a tun of 2,000 pounds, including friction, on a level plane and up the different inclines, in pounds.
Level.	Level.	Level.	Level.	96	16
1 in 100	1	52.8	0° 34' 23"	216	36
1 " 50	2	105.6	1° 08' 45"	336	56
1 " 33 1-3	3	158.4	1° 43' 06"	456	76
1 " 25	4	211.2	2° 17' 26"	576	96
1 " 20	5	264.0	2° 51' 44"	696	116
1 " 16 2-3	6	316.8	3° 26' 01"	816	136
1 " 14 2-7	7	369.6	4° 00' 15"	936	156
1 " 12 1-2	8	422.4	4° 34' 26"	1056	176
1 " 11 1-9	9	475.2	5° 08' 34"	1176	196
1 " 10	10	528.0	5° 42' 38"	1296	216

Relative Weight or Load Capable of Being Moved on a Level Plane and on Different Inclines by the Same Power.

By assuming the condition of the road, both on a level and on the different inclines to be equal, and the weight of the car and its load and other things remaining the same, the relative difference between a given load drawn along a level plane, and that drawn along different inclines, with the same power and velocity, may be taken, with sufficient accuracy for all practical purposes, as follows:

Suppose the load that a horse is capable of drawing on a level road, at the rate of 4.4 feet per second, or three miles an hour, be taken as a unit, then

On an incline of	1	in	100	he can draw	9-10	as much as	on a level road	with the same velocity.
"	1	"	50	"	81-100	"	"	"
"	1	"	44	"	3-4	"	"	"
"	1	"	40	"	72-100	"	"	"
"	1	"	33⅓	"	67-100	"	"	"
"	1	"	30	"	64-100	"	"	"
"	1	"	25	"	52-100	"	"	"
"	1	"	24	"	1-2	"	"	"
"	1	"	20	"	4-10	"	"	"
"	1	"	15	"	33-100	"	"	"
"	1	"	10	"	1-4	"	"	"
"	1	"	8	"	22-100	"	"	"
"	1	"	7	"	1-5	"	"	"

Assuming in each case that the horse exerts the same amount of force, though it is calculated that, for a short time, he is capable of doubling his exertion over what he should do on a level road.

For a practical case we will take Vineyard Street in Cleveland, Ohio, as an example of the maximum grade for horse power. This Street has a grade of 1 in 11 1-9, or nine ft. in 100 feet, for a distance of five hundred feet, over which the West Side Street Railway passes. The two-horse cars used on that road weigh about 3,600 pounds each, carrying, on extra occasions, as many as sixty-five passengers up the

grade with only three horses! But taking fifty-six passengers, with an average weight of 150 pounds each, the maximum load would then be:

Weight of car, ...	3,600 pounds.
56 Passengers, at 150 pounds each, ...	8,400 "
Maximum load six tuns, or, ...	12,000 pounds.

The tractive force of which on a gradient of 9 feet in 100 feet (taking the tractive force on a level way at 1-125 of the load,) is 1,176 pounds; one-third of which, or 392 pounds, is therefore the real force exerted by each horse in drawing the load up the gradient of 9 feet in 100 feet. Although this incline is much greater than is desired, and more than was considered as being practical to operate upon successfully, yet there has been no real difficulty in drawing the cars with a load of thirty, or even forty passengers up the grade with three horses, in the different seasons of the year and conditions of the road. If we take the available power of two horses in the same ratio, at 784 pounds, which is double what it should be in ordinary cases with the same load, we shall have $\frac{784}{12000}$=15.31, so that the gradient should not exceed 1 in 15.31 feet, or about 6.53 feet in 100 feet, to perform the same work with two horses that now requires three.

Where it is practicable the maximum gradient should not exceed 1 in 20 or 5 in 100 for horse power, and 1 in 25 or 4 in 100 for steam with the "Dummy Engine."

The following testimonials, in reference to our improved Railroad Turnout, fully explain themselves:

TESTIMONIALS.

OFFICE OF THE KINSMAN STREET R. R. Co.,
CLEVELAND, O., May 26, 1866.

To whom it may Concern:

This Company a few weeks since put in one of Mr. I. N. Pillsbury's Switches, patented Dec. 22, 1863, and is entirely satisfied with its operation. I have no doubt that the saving of Cars, Horses, &c., by the use of this Switch will pay its cost every year, besides obviating the general tendency to "off track," so general on all single track roads. One of the distinctive features of this Switch is, that it guards against the *negligence* of drivers, requiring no more care than a strait track. Every part of it is fixed, and no more liable to get out of order than any other portion of the track.

E. G. WILLIAMS,
President.

OFFICE OF THE TOLEDO STREET R. R. Co.,
TOLEDO, OHIO, May 1, 1867.

I. N. Pillsbury, C. E., Cleveland, O.,

SIR:—YOUR IMPROVED RAILROAD TURNOUT, patented Dec. 22, 1863, and put down upon our road in July last, is entirely satisfactory to the Company. As every part is a fixture, there is no liability to get out of order more than on any other part of the road; and as each car, upon entering the Turnout, keeps the *right hand track without turning from a straight line* until after all the connecting points of the two tracks are passed, it is equally adapted to railways for steam power with the DUMMY ENGINE. There is no "pulling over" or "off track," either upon entering or leaving the Turnout; and being a fixture, of course, no switchmen are required. The saving of Cars, Horses, wear of Tracks, &c., by the use of this Turnout over those in general use, is very great; besides, the cars pass over it smoothly and safely with the horses upon a trot the same as on any other part of the road. In fact the plan is unexceptionable, as the principle of entering the Turnout and passing the points of the double tracks in straight lines *cannot be improved.* And being fully satisfied with its practical working, we take a pleasure in recommending this Turnout to city and suburban railway companies generally for adoption.

E. P. BASSETT, Pres't.
C. S. PECK, Sup't.

The undersigned having adopted I. N. Pillsbury's Improved Railroad Turnout, upon our roads, and thoroughly tested its utility by actual use, during the past year, to our entire satisfaction, wholly concur in the statements made in the foregoing testimonials; and being *fully satisfied* with its practical working, we take pleasure in recommending the adoption of this Turnout by other companies, either for horse power or the "Dummy Engine."

A. EVERETT, President, and
E. DUTY, Superintendent of the
E. C. R. R. Co.
JAS. M. COFFINBURY, Pres't,
M. ANDREWS, Sup't, and
A. V. STANARD, former Sup't and
Constructionist of the Westside St. Railway Co.,
at Cleveland, Ohio.

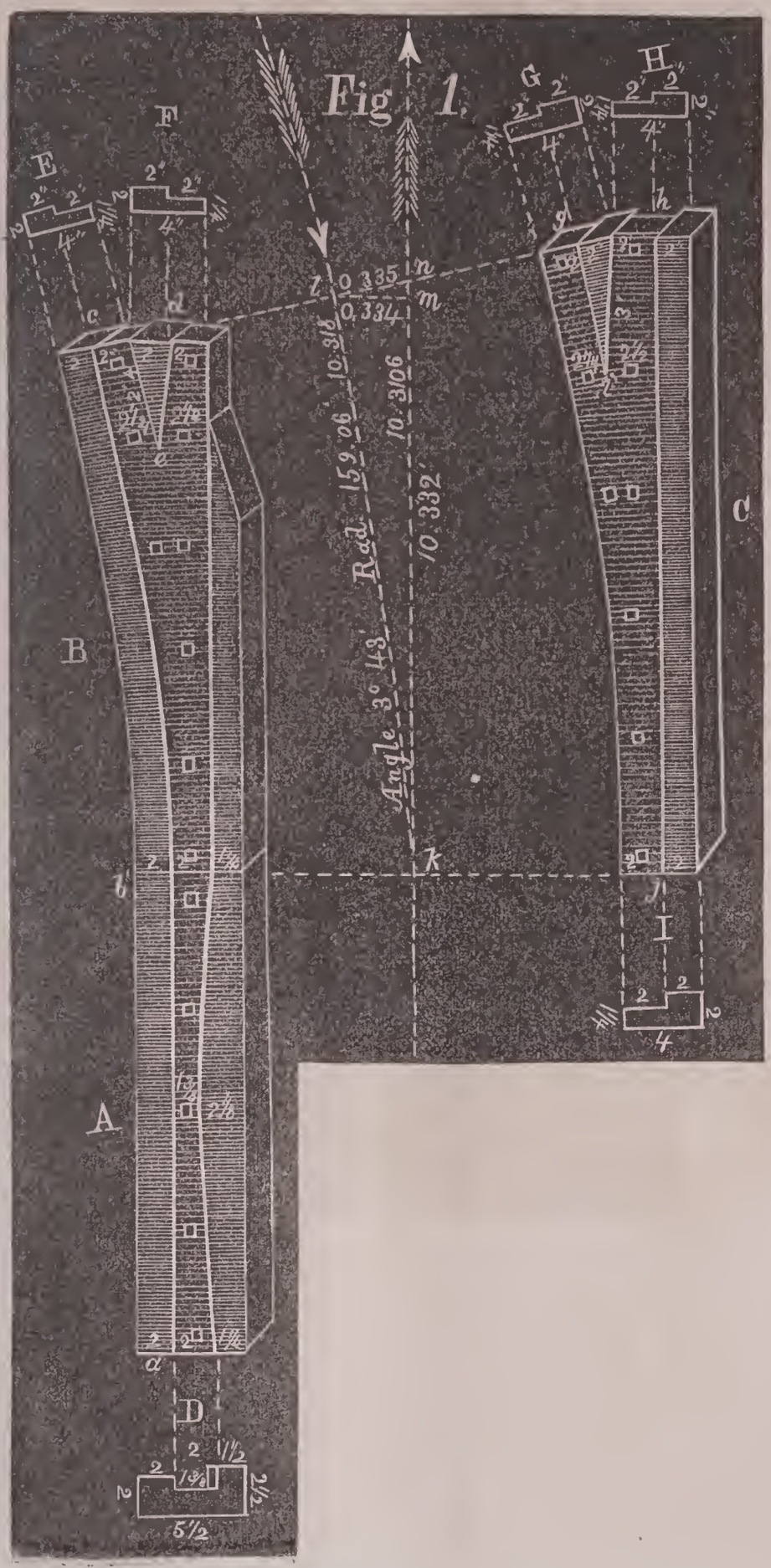
CLEVELAND, OHIO, May 13, 1867.

I. N. Pillsbury, Esq., Civil Engineer:

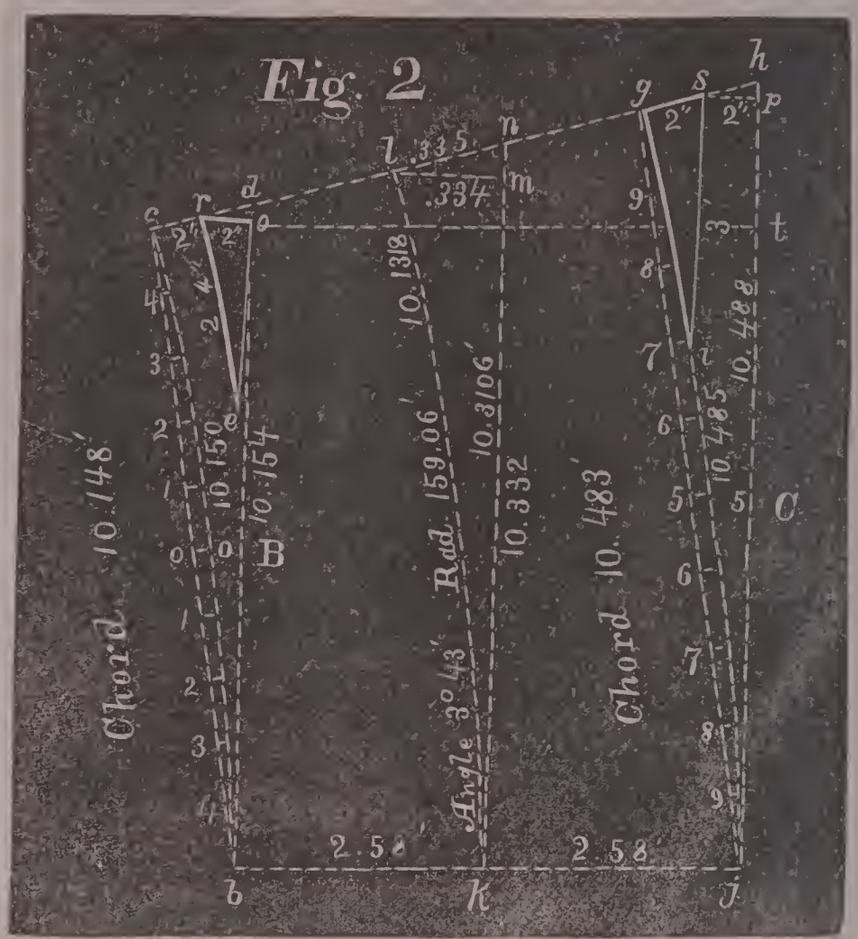
DEAR SIR:—I have examined your "Patent Railroad Turnout," designed principally for Street Cars, and I have no hesitation in stating that in my judgment it has great value; and had I Street Railroads to construct, I should adopt it at any reasonable cost for the use of the Patent.

Respectfully, yours, A. STONE, JR.

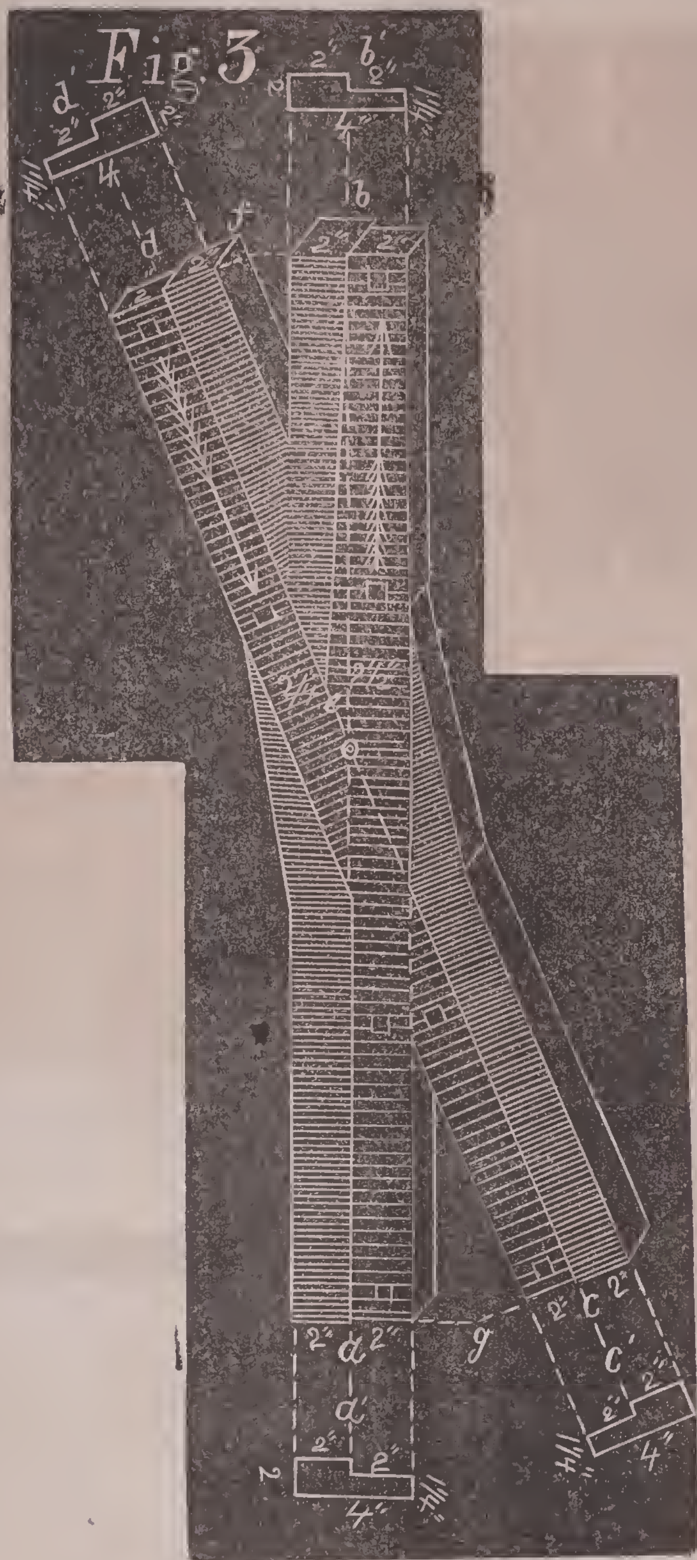
Cast Iron Plates and Guard Rail.



Lines of Reference for Plate Patterns.



Cast Iron Frog.



Chair for Guard Rail at *a*, Fig. 1.

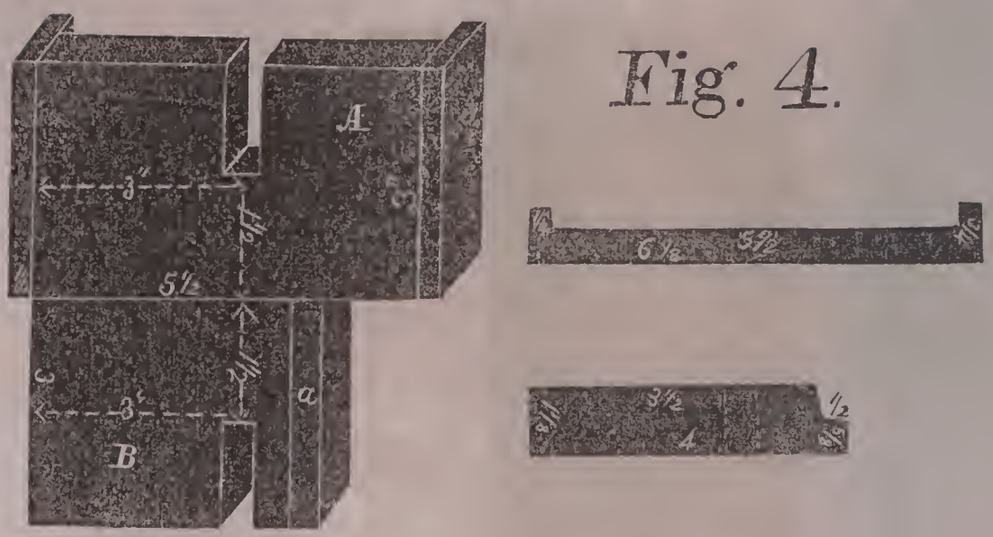


Fig. 4.

Chair for Guard Rail and Plate at *b*, Fig. 1.

Fig. 5.

Chair for Plates and Frogs, at *c*, *d*, *h*, and *j*, Fig. 1. and *a*, *b*, *c*, and *d*, Fig. 3.

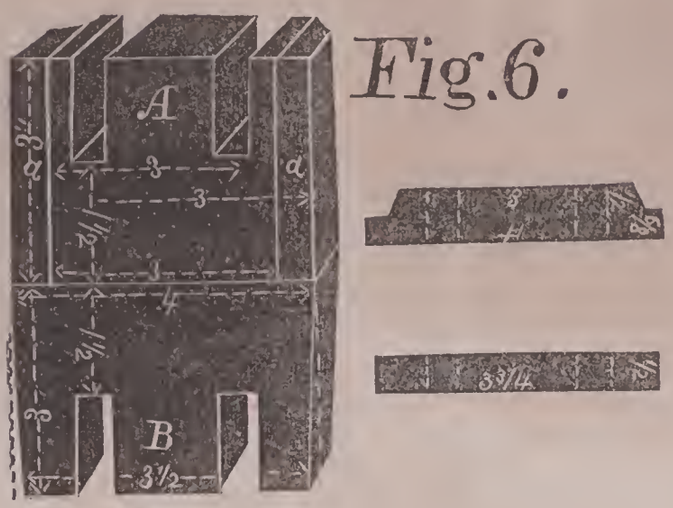
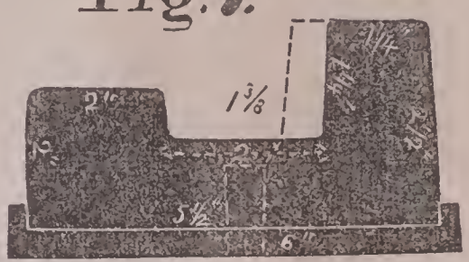


Fig.6.

Section of Guard Rail, at *a*, *b*, and *A*, Fig. 1.

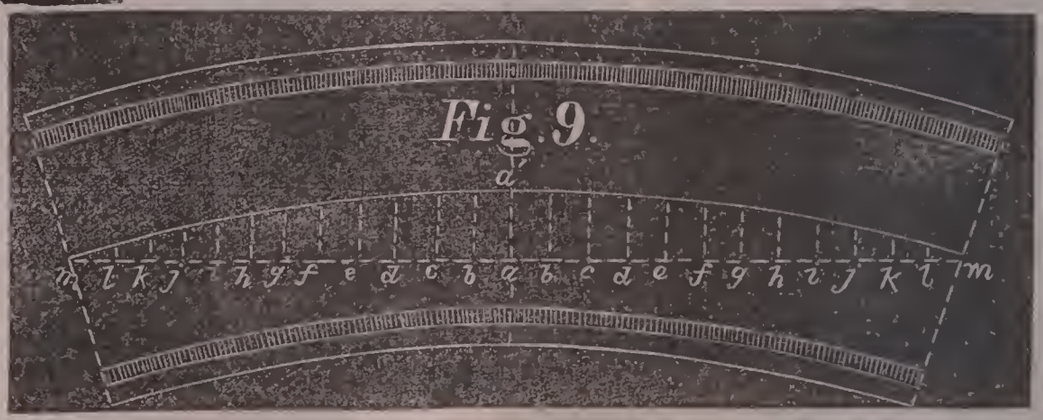
Fig.7.



Spikes for Plates, Frogs, and Guard Rails.

Fig.8.

Plan for Making Center Board and Pattern for Curving Rails.



Joint Plate and Section of Street Rail.

Fig. 10.

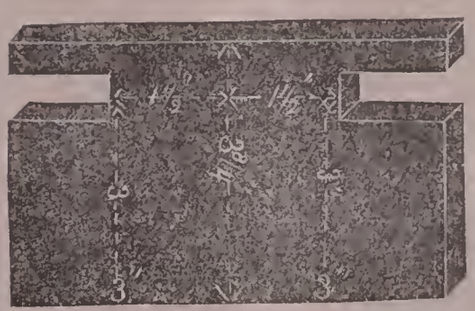
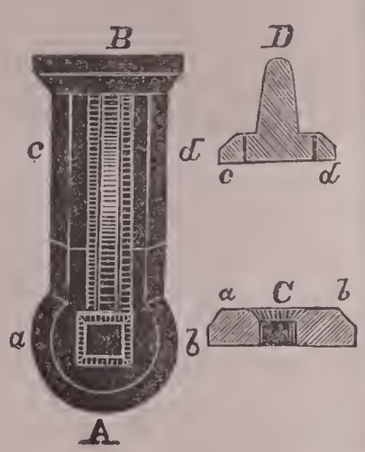


Fig. 11.

Plan and Section of Cast Iron Stays.

Fig. 12. *Fig. 13.*



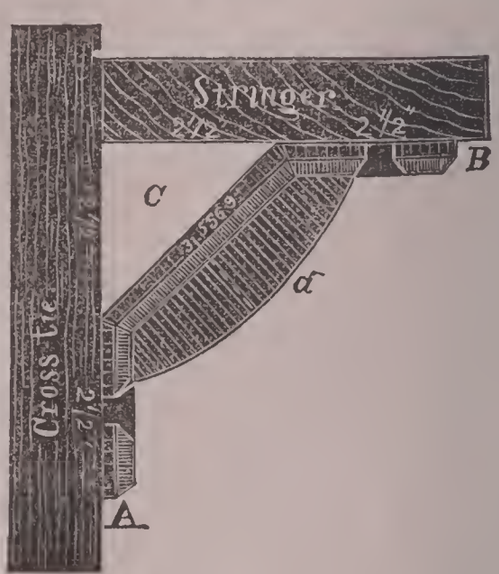


Table No. 8.

Centre radii and angles, and length of arcs for 14 degree curves, Fig. 14; turn-out plates equal a 36° 38m 34s, curve. Guage of track, 4 feet 8½ inches.

Arcs,	Centre Radii Feet.	Centre angles	Length of Arcs in Feet.		
			Inner.	Center.	Outer.
A N & H G Plates	159.06	3° 43' 00"	10.165	10.318	10.470
N M & G F,	410.30	4° 17' 00"	30.497	30.673	30.849
L K & E D,	410.30	8° 00' 00"	56.960	57.289	57.617
BC, CD, LJ & JK,	410.30	8° 57' 14"	63.752	64.119	64.486
Angle of frogs,		8° 00' 00"		Radii.	
Turn-out plates,		3° 43' 00"	156.710	159.06	161.41

Table No. 9.

Length of rails, exclusive of the plates and frogs, for the entire turn-out, as follows:

Straight rails for main track, 410.740 }		
" " for frog tongents 61.056 }	471.796	feet.
Curved rails for inside of tracks	429.922	"
" " " outside of tracks	434.876	"
Total for the turn-out, of 4 feet 8½ inches gauge	1,366.594	"

Following are the dimensions of the several parts of a turn-out, with fourteen degree curves (410.3 feet radii) and eight degree frogs, for a gauge of track of four feet eight and a half inches (4.70 feet) and a distance of ten feet between the centres of the two tracks, measuring at right angles with the line A O H (Fig. 14) at the points B O and I

Table No. 4.

Straight lines, Fig. 14, for Turn-out of 14 degree curves.	Length in feet
From A to B	116.007
" B to O 63.859 } from B to I	127.718
" O to I, 63.859 }	
" I to H	116 07
" A to H, extreme length	359.732
" point of frogs to A and H, on line of rails	49.768
" " " to e and j, to point of curve	8.708
" " " to f and i, " "	9.556
" e to f, and i to j, tangents crossing tracks	18.264

For a gauge of track of five feet two inches (5,16 feet) the following dimensions, other things being equal, are to be substituted, viz:

From point of frogs to A and H, read	53.025	feet,
" " " to e and j, "	11.966	"
" " " to f and i, "	6.298	"
Frog tangent, same as 4' 8½" gauge	18.264	"

IMPROVED RAIL ROAD TURN-OUT,

BY

I. N. PILLSBURY, CIVIL ENGINEER, CLEVELAND, O.

PATENTED DECEMBER 22, 1863.

Fig 14.

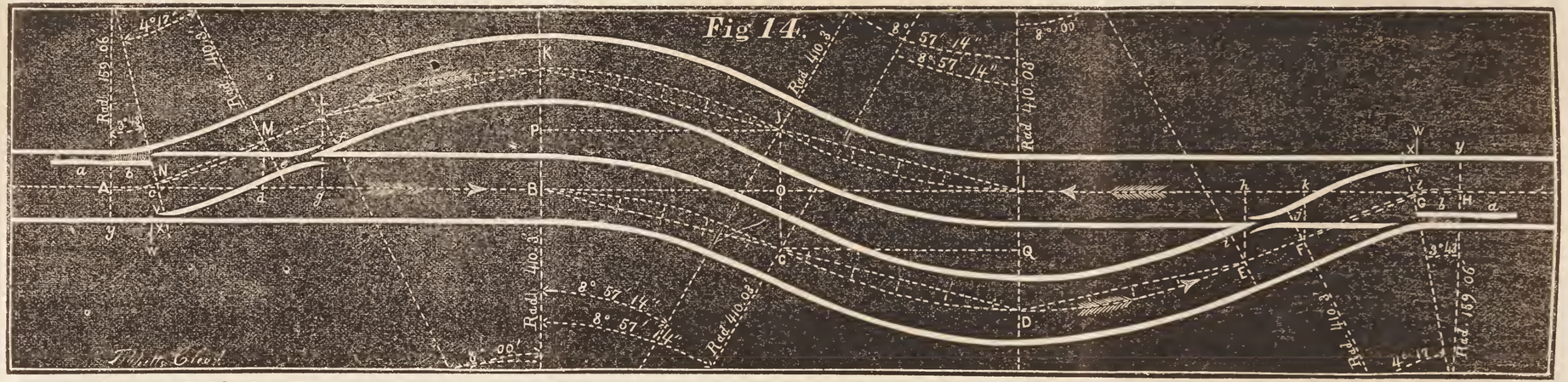


Table No. 5.

Centre line of tracks, Fig. 14, for Turn-out of 14 deg. curves.	Length in feet
Tangents A B and H I	116.007
Reverse curves B C D and I J K	128.238
Curves D E and K L	57.289
Tangents E F and L M	18.264
Curves F G and M N	30.673
Curves G H and N A plates	10.318
Length of Turn-out, on center line of tracks	360.789
" " " in a straight line	359.732
Difference in length from a straight line	1.057

Table No. 6.

Distances on the straight line A O H, and offsets at right angles therewith, to points in the center line of the tracks. For turn-out of 14 degree curves, Fig. 14.

Points on line A O H	Dis. in feet from A & H	Offsets.	Length in Feet.
A c and H *l*,	10.3106	c N and *l* G,	0.334
A d and H k,	40.8181	d M and k F,	3.465
A g and H h,	58.9043	g L and h E,	6.007
A B and H I,	116.0070	B K and I D,	10.000
B O and I O,	63.8590	O J and O C	5.000
Intermediate Distances.			
A c and H *l*,	10.3106	c N and *l* G,	0.334
c d and *l* k,	30.5075	d M and k F,	3.465
d g and k h,	18.0862	g L and h E,	6.007
g B and h I	57.1027	B k and I D,	10.000
B O and I O,	63.8590	O J and O C,	5.000

Table No. 7.

Chords and Ordinates, ten feet apart, from the middle of the chord, for the center line of the tracks; for turn-ont of 14 deg. curves, Fig. 14.

Chords.	Length in Feet.	Ordinates ten feet apart.				
		20 feet. Feet.	10 Feet. Feet.	Middle. Feet.	10 Feet. Feet.	20 Feet. Feet.
A N and H G,	10.316			0.084		
N M and G F,	30.666		0.165	0.287	0.165	
L K and E D,	57.242	0.512	0.878	1.000	0.878	0.512
BC, CD, LJ & JK	64.054	0.764	1.130	1.252	1.130	0.764
Same chords with Ordinates in inches.						
A N and H G,				1 0-16		
N M and G F,			2 0-16	3 7-16	2 0-16	
L K and E D		6⅛	10 9-16	12	10 9-16	6⅛
BC, CD, LJ & JK		9⅛	13 9-16	15	13 9-16	9⅛
T'ng's ML & FE	18.264					

The undersigned will furnish working plans of the cast iron plates, frogs, [illegible]d rails, chairs, &c, with full directions for putting down the turn-outs, to parties purchasing the right to use them; and is also prepared to sell the exclusive right for States, Counties, and Cities, or the right to construct [illegible]em for single roads, upon reasonable terms. Any further information will be furnished, by addressing,

I. N. PILLSBURY, C. E., Cleveland, Cuyahoga County, Ohio.

Table No. IV.

Centre radii and angle, and length of arc for 1° degree curves, 100 feet chord, equal 30.48 metres. Change of track, 4 feet 8½ inches.

Arcs.	Centre Radii.	Centre Angle.	Length of Arcs in Feet.	
			Inner.	Outer.
1 to 2 of 1 Degree	1,145.92	5° 00′ 00″	100.00	100.00
3 to 4 of 1 Degree	1,145.92	5° 00′ 00″	100.00	100.00
5 to 6 of 1 Degree	1,145.92	5° 00′ 00″	100.00	100.00
7 to 8 of 1 Degree	1,145.92	5° 00′ 00″	100.00	100.00
Total of 8 Degrees		40° 00′ 00″	800.00	
Tangents, 10 to 11			100.00	100.00
Tangents, 11 to 12			100.00	100.00
Tangents, 12 to 13			100.00	100.00
Tangents, 13 to 14			100.00	100.00
Total of Tangents,		0° 00′ 00″	400.00	
Transitional Curves,		9° 45′ 00″	139.36	139.36

Table No. V.

Length of rails, centrewise of the plates, and Degree corresponding thereto, are as follows:

Straight rails for tangents	1,000	30.480 metres.
" " curves	500	15.240 "
Transitional rails for tangents to curves	500	15.240 "
" " curves	500	15.240 "
Total length of one set, of 1 foot 9" gauge	2,500	76.200 "

Including curves of 1 degree (1,145.92 feet radius) and eight degree curves (143.3 feet radius) and eight degree curves (143.3 feet radius) or four 4 degree curves (286.6

Improved Rail Road Turnout No. 2, Fig. 15.

This Turnout, No. 2 Fig. 15, is an improvement on my original patent No. 1 Fig. 14, whereby the space occupied by the double tracks is equally divided on each side of the center line of the street, thereby giving better satisfaction to the property owners along the line of the road as well as to the city authorities generally.

The same pattern of cast iron plates, frogs, guard rails and chains used for my original patent, Fig. 14, is also used for this in the same manner, excepting, *only*, the position of the frog plates is changed so as to divide the angle of the frogs equally between the right and left hand tracks. By this plan the amount of curvature, in passing over the Turnout, is reduced from 226.518 feet, to 97,036 feet, without changing the radii or degree of curvature. And as the same pattern of cast iron plates and guard rails used for Fig. 14 are also used in the same manner for this, of course the principle upon which the cars enter the Turnout in the same straight lines and pass the points of the plates before turning from that line, is identically the same in both.

Therefore, this Turnout, like Fig. 14, is equally adapted to Railways for either horse or steam power cars with the "Dummy" Engine. Every part is a fixture and therefore not liable to get out of order. Both ends are in the same straight line. The cars enter and pass over the turnout in the direction indicated by the arrows; the inclined guard rails y y' in connection with the guards x x' on the inside plates, ease the cars off from the curves, H I and P A, to the tangents of the main track, upon leaving the Turnout, without any apparent jerking or jolting, even at a velocity of five or six miles an hour. Each car upon entering the Turnout, keeps the right hand track without turning from a straight line, until after all the points of the plates are

passed. The tracks also cross each other in straight lines, thereby dispensing with the use of guard rails opposite the points of the frogs. There is no "pulling over" or "off track" either upon entering or leaving the Turnout. It is simple in its form of construction, and can be made of any desired length, without changing the radii or degree of curvature. The cast iron plates, frogs, guard rails, chains, &c., are represented in detail by separate figures accompanying the specifications and directions for putting them down. As before remarked, these Turnouts have been thorougly tested, and their utility fully and practically demonstrated to the entire satisfaction of the parties using them, so that we are not offering them for adoption generally, simply as an experiment with doubtful results, but as an improvement fully determined to be just what is required on all city and subarban railways, for either horse power cars, or steam power with the "Dummy" Engine.

Following are the directions for putting down Turnout No. 2, Fig. 15.

Directions for Putting down Turnout No. 2, Fig. 15, with 14 Degree Curves, (Center Radii 410.3 feet,) and Angle of Frogs 8 Degrees.

Having fixed upon the location and determined upon the length of the Turnout, say from 220 to 250 feet generally, measure and fix the points A and I in the center line of the street at each end of the Turnout; then put down the cast iron plates and guard rails (Fig. 1,) placing the small end of the plate opposite the point A and I, at right angles with the center line of the street or Turnout. Then measure from the points A and I, along said center line, 10.5 feet, and fix the points B and I for the points of curve for the right hand tracks; then measure from A and I, along said center line, 11.095 feet, and fix the points a and l, and from the points a and l measure, at right angles with said center

line, 0.388 feet and fix the points of tangent P and H in the left hand tracks; then measure from A and I, along said center line, 39.121 feet, to the points b and k, and from these points measure, at right angles with said center line, one foot to the tangent points C and K in the center line of the right hand tracks; then measure from A and I, along said center line, 62.749 feet to the points c and j, and from these points measure at right angles four feet to the point of curve O and G in the center line of the left hand tracks; then measure from A and I, along said center line. 82.023 feet to the points d and i, and from these points measure, at right angles, four feet to the points of curve D and L; then from A and I measure along said center line 91.370 feet to the points e and h, and from these points measure, at right angles, five feet to the tangent points N and F; and then from A and I measure along said center line 110.644 feet to the points f and g, and from these points measure, at right angles, five feet to the tangent points E and M.

Having thus fixed the points in the center line of the tracks at A, B, C, D, E, F, G, H, I, J, K, L, M, N, O and P, bi-sect the chord lines BC, DE, FG, JK, LM, and NO; and from said bi-secting points measure, at right angles with said chord lines, the middle ordinates, 0.250 feet to the center line of the tracks. Then a line stretched between the points CD, EF, GH, KL, MN, and OP will form the center line of the tangents from which to gauge the rails of the tracks; and the center line of the curves between the points BC, DE, FG, JK, LM, and NO may be fixed with the center board as described in Fig. 9.

To determine the true position of the frog plates for any gauge of track: First for the point Q measure from the points C, D, O, and P, the lines Co, Dp, Om, and Pn, each equal in length to one-half of the required gauge of track; then lines drawn between the points mn and op will inter-

sect each other at the point Q, which is the true place for the *real* point of the frog. For the point V, measure in like manner from the points G, H, K, and L, the lines Gw, Hx, Kr, and Ls, each also equal in length to one-half of the the required gauge of the track, and the intersection of the lines wx and rs will give the required point V.

The straight lines EF and MN may be made any desired leugth without changing the degree of curvature in the Turnout, affecting only its entire length; or, *if necessary*, the tangents in the middle of the Turnout may be left out altogether, thus making the turnout short enough for the passage of only a single car, making the extreme length from A to I only 202.014 feet. The left hand side of the track should be elevated at least one-half an inch above the right hand side, commencing at a point forty or fifty feet before entering the turnout, and extending as far as the frog plates, the same as described for Turnout No. 1, Fig. 14.

Turnout No. 2, Table No. 23.

Distances on the straight line AI, and offsets at right angles therewith, to points in the center line of the tracks for Turnout, with 14 deg. curves and frog, angle 8 deg., Fig. 15.

Points on line A I.	Distance in feet from A & I.	Offsets.	Length in Feet.
A B and I J,.....	10.500	.....	.....
A a and I l,.....	11.095	a P and l H,	0.388
A b and I k,.....	39.121	b C and k K,	1.000
A c and I j,.....	62.749	c O and j G,	4.000
A d and I i,.....	82.023	d D and i L,	4.000
A e and I h,.....	91.370	e N and h F,	5.000
A f and I g,.....	110.644	f E and g M.	5.000

Table No. 24.

Chords and ordinates ten feet apart from the middle of the chord, for center line of the tracks, 14 deg. curves. Fig 15.

Chords.	Length in feet.	Ordinates 10 feet apart.		
		10 feet. Feet.	Middle. Feet.	10 feet. Feet.
BC, DE, FG, JK, LM & NO, ...	28.638	0.128	0.250	0.128

Table No. 25.

Arcs with their center radii, angles and length in feet for Turnouts with 14 degree curves, Fig. 15.

Arcs.	Center radii in feet.	Central Angles.	Length of center arc in feet.
Plates,	159.06	3° 43' 00"	10.318
BC, DE, FG, JK, LM and NO,	410.30	4° 00' 00"	28.644
AP and IH,	159.06	4° 00' 00"	11.104
Angle of frogs,	.....	8° 00' 00"	.....

Table No. 26.

Center Line of Tracks for Turnout No. 2, Fig. 15.	Length in Feet.
Tangents AB and IJ,	10,500
Curves BC and JK,	28,644
Tangents CD and KL,	43,006
Curves DE and LM,	28,644
Tangents EF and MN, (variable,)	47,986
Curves FG and NO,	28,644
Tangents GH and OP,	51,780
Curves HI and PA,	11,104
Length of Turnout in center line of tracks,	250,308
" in a straight line,	250,000
Difference from a straight line,	0,308

The straight tracks in the middle of the Turnout, or tangents EF and MN, may be made longer or shorter as desired; or, they may be left out entirely and thereby make the Turnout short enough for the passage of a single car only, without shortening the curves.

Quantity of Materials for a Turnout 250 Feet Long, No. 2, Fig. 15.

140 Cross Ties, 5x6 in., 6 f. 9 in. to 7 f. long.

1000 Linear feet of Stringers, same width of street rail, and 6 in. deep.

343.728 feet of Curved Rails, } 722.872 linear feet.
379.144 " " Straight " }

4	Cast Iron Plates, B and C, Fig. 1,	1240 lbs.
2	" " Frogs, (Fig. 3,)	436 "
2	" " Guard Rails, (A, Fig. 1.)	496 "
22	" " Chairs, (Fig's 4, 5, & 6,)	120 "
250	" " Stringer Stays, (Fig's 12 & 13,)	438 "
	Amount of Castings,	2730 lbs.

40	Wrought Iron Joint Plates, $1\frac{1}{2}$ lbs. each,	60 lbs.
62	Square Headed Spike for Castings, (Fig. 8,)	31 "
400	Street Rail Spike, $4\frac{1}{2}$x$\frac{1}{2}$ in.....	128 "
300	Stringer Spike, 10x7-16 in.....	240 "

The above quantities are for both tracks. The cost will, of course, vary according to the price of materials and labor in the different localities.

We are prepared to sell the exclusive right to use these Turnouts in States, Counties, and Cities, or the right to construct them on single roads, upon reasonable terms. Any further information will be furnished by addressing,

I. N. PILLSBURY, C. E.,
Cleveland, Cuyahoga Co., O.

OFFICE OF SUPERIOR & ST. CLAIR STREET RAILWAY CO.,
CLEVELAND, OHIO, October, 1867.

To all whom it may Concern:

This Company would respectfully state that they have adopted and are now using upon their road, I. N. Pillsbury's "Improved Rail Road Turnout," and that the Company are fully satisfied with its operation in every particular, and therefore recommend its adoption upon other roads, as being equally adapted for cars with horse power, or for steam with a "Dummy Engine."

R. F. PAINE, President, and
D. ATWOOD, Superintendent of the
Superior & St. Clair St. Railway Co.

The undersigned fully concur in the above statement.

A. EVERETT, President, and
E. DUTY, Superintendent of the
East Cleveland St. Railroad Co.

ERRATA.

Page 8, line 19 from top, chord j g, *for* 10.433 *read* 10.483.

" 9, " 2 from bottom, *for* A *read* a.

" 13, table No. 3, Middle Ordinates, *for* 14° curves and 10 feet rails, *read* $\frac{3}{8}$ —; 14 feet rails *read* $\frac{11}{16}+$; 15 feet rails *read* $\frac{13}{16}+$; and 16 feet rails *read* $\frac{15}{16}$.

" 13, line 9 from bottom, *for* $\left(\frac{\frac{L}{2}^2}{4R}\right)$ *read* $\left(\frac{\frac{L}{2}^2}{2R}\right)$

" 13, line 8 from bottom, *for* $\frac{L2\times1\frac{1}{2}}{R}$ *read* $\frac{L2\times1\frac{1}{2}}{R}$.

" 20, in Table No. 16, in column of Arcs, at bottom, *for* Tangent *read* Turnout.

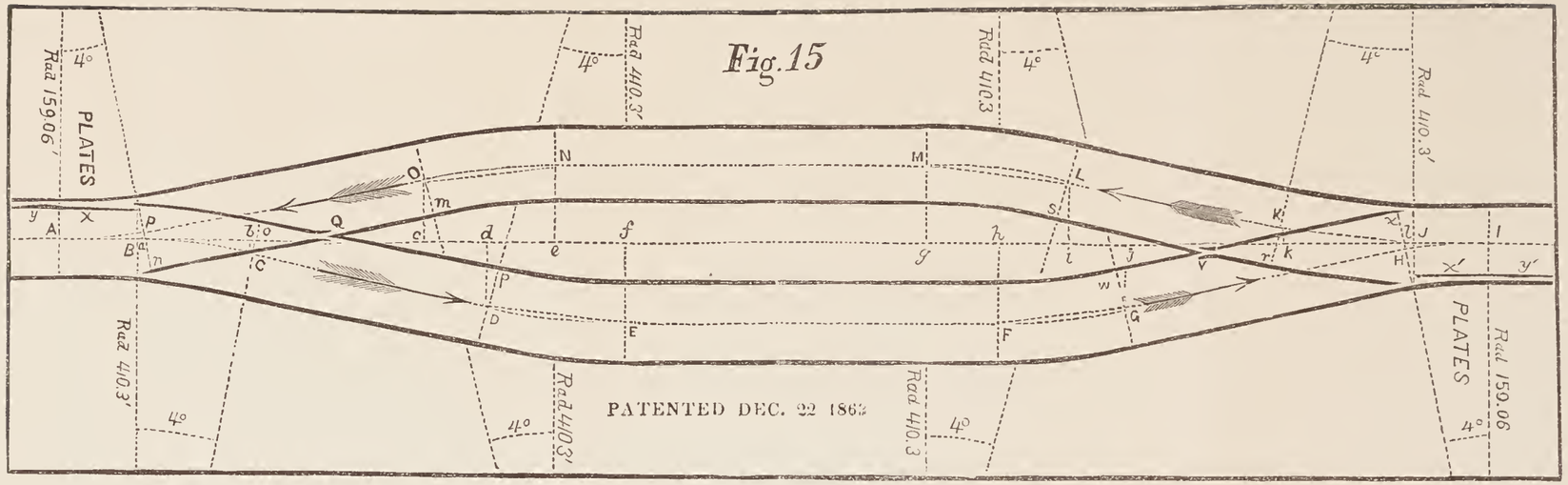
" 42, in Center Arc, Fig. 2, *for* 10.1318' *read* 10.318'.

" 46, in Fig. 11, for the lip of the rail, the letter *a* was omitted by the engraver.

" 47, line 8 from top, *for* chains *read* chairs.

" 48, " 7 from top, *for* chains *read* chairs.

" 48, " 7 from bottom, *for* plate *read* plates; and *for* point *read* points.



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